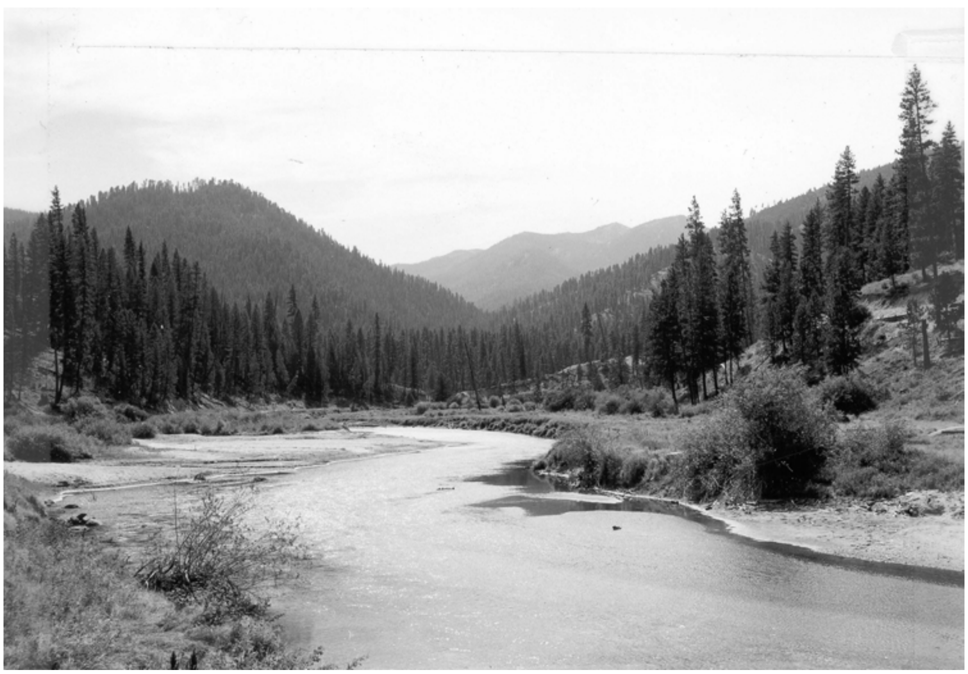
DEPOSITION OF FINE SEDIMENT IN THE SOUTH FORK SALMON RIVER AND CHAMBERLAIN CREEK WATERSHEDS PAYETTE AND BOISE NATIONAL FORESTS, IDAHO

INTRAGRAVEL CONDITIONS IN SPAWNING AREAS

REPORT OF SEDIMENT TRENDS FROM CORE SAMPLING, 1966-2000



South Fork Salmon River near Camp Creek, 1955

RODGER L. NELSON, FISHERIES BIOLOGIST, PAYETTE NATIONAL FOREST
DAVID C. BURNS, FOREST FISHERIES BIOLOGIST, PAYETTE NATIONAL FOREST
DONALD D. NEWBERRY, FISHERIES BIOLOGIST, BOISE NATIONAL FOREST

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EXECUTIVE SUMMARY

The South Fork Salmon River (SFSR) system was historically one of the most important producers of Snake River spring/summer chinook salmon (*Oncorhynchus tschawytscha*) in Idaho, and continues to provide spawning and rearing habitat for threatened anadromous salmon and steelhead (*O. mykiss gairdneri*). In addition to these species, the river system also supports anadromous Pacific lamprey (*Lampetra tridentata*) and several native resident salmonids, including bull trout (*Salvelinus confluentus*), recently listed as threatened, westslope cutthroat trout (*O. clarki lewisi*), redband trout (*O. mykiss gairdneri*), and mountain whitefish (*Prosopium williamsoni*), as well as introduced brook trout (*S. fontinalis*). This large watershed has also been important for production of other forest resources, including timber, forage, minerals, and recreation.

Many of the granitic hillslopes in the SFSR watershed are steep and erode readily. In the winter of 1964-65, there were two extreme weather events with heavy rain falling on snow. This led to severe erosion on many hillsides, some of which were destabilized by logging roads. Large amounts of hillslope material made their way into the main channel of the SFSR, blanketing many important spawning and rearing areas with fine sediments; the Secesh River watershed, an important tributary to the SFSR, was also affected, but primarily in its lower reaches near its confluence with the SFSR. Since that time, timber harvest has been restricted in the main SFSR watershed to avoid exacerbating the situation, and annual monitoring of subsurface material in spawning areas indicates that sediment conditions in the river have gradually improved but are approximately stable.

Because of the importance of the SFSR watershed to anadromous fish, sediment monitoring is conducted on both the Payette and Boise National Forests, who share administration of the watershed. This monitoring includes annual sediment cores in the mainstem SFSR, in the Secesh River watershed, a principal tributary of the SFSR, and in Chamberlain Basin, a largely undeveloped area with geology similar to that of the SFSR watershed.

We have found that subsurface fine sediments measured by core sampling are generally decreasing slowly in the mainstem SFSR, though considerable annual variation was evident. Subsurface fines have been generally increasing in the Secesh River watershed since 1981, but have probably reversed their trend and begun a downturn beginning about 1990. This reversal of trend in the Secesh River watershed coincides with watershed improvements initiated prior to and in conjunction with the current Payette National Forest Land and Resource Management Plan (Forest Plan) released in 1988. In the Chamberlain Basin, a control watershed in the Frank Church River of No Return Wilderness, subsurface fines are behaving in a fashion similar to spawning areas in the mainstem SFSR, with a generally downward trend except for an apparent increase in 1996.

In some cases, apparent sediment trends varied with the size class of fine sediments (<6.33mm, <4.75mm, and <0.85mm) being considered. The most frequent situation in this regard is represented by either a stronger or opposing trend for the smallest particles. This may be due to difficulties in separating these smaller particles in the field, though the relatively small annual variation suggests that differences in trend are real for many sites. In the Poverty Flat spawning area in the mainstem SFSR, for example, there is no apparent trend in large fine sediments (<6.33mm) but a very strong declining trend for small fines (<0.85mm) and an upward trend in geometric mean particle diameter, suggesting continued coarsening of the streambed. Spawning gravel quality is clearly better in Chamberlain Creek and most Secesh River sites, but is more difficult to interpret in the SFSR. Two sites in particular, Dollar Creek and Glory Hole, appear to be accumulation areas from which deposited material is removed more slowly. Flooding and high flows in several recent years have resulted in deposits in these areas that have not been transported as effectively as elsewhere. However, spawning gravel quality was good in all SFSR sites in 2000.

Perhaps the most significant result of this monitoring effort to date is that we have sufficient information to believe that the rehabilitative and mitigative measures in both the SFSR and Secesh watersheds have been effective in restoring a great deal of resiliency to these systems. It is unlikely that the conditions that existed prior to development have been restored, but there has been a multitude of potentially destabilizing natural events in recent years. Just since 1994, these have included large wildfires, floods, hillslope failures from mid-winter rain-on-snow, and extreme spring flows; however, none have resulted in obvious deposition of fine sediments as occurred in the SFSR in 1965.

Some of the monitoring reported here was established to evaluate the practicality of renewing timber harvest and other discretionary land disturbing projects in the SFSR. Given the improvements that we see in the watershed, resumption of limited discretionary land disturbing projects, as envisioned by the current Forest Plans for the Boise and Payette National Forests may be reasonable if coupled with increased monitoring and actions are limited to very small scale. Implementation of the steps leading to some such projects, along with concurrent mitigation, monitoring, and rehabilitation efforts, seems appropriate in our view, but not without the acceptance of some added risk.

It is important to understand that this report is not intended to stand alone or to evaluate the effects of any individual project. Instead, it should be used in conjunction with the most recent interstitial sediment monitoring report for SFSR tributaries and with project-specific monitoring reports. Although the interstitial sediment monitoring is done annually, our ability to critically evaluate some timber salvage projects undertaken after the 1994 wildfires has been limited because project-level monitoring was abandoned. We have also discontinued monitoring at several sites that were designed to assess feasibility of future actions. In order to be consistent with the Forest Plans' intentions to allow stepwise re-entry in the SFSR, these monitoring efforts should be reactivated for several years before implementation of future timber harvest or other discretionary land disturbing projects.

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INTRODUCTION

Streams in the central Idaho mountains support a variety of native anadromous and resident fishes, as well as many introduced species. Although fish habitat varies naturally in response to variation in the intensity and timing of natural processes, forest management activities have altered the ecosystems in which fish habitat in these streams has developed. Sediment, for example, is an important natural component of fish habitat, and in the absence of anthropogenic or cataclysmic natural disturbance, sediment deposition and transport are typically considered to reach some sort of equilibrium to which local fish species are adapted. Although the actual amount of sediment fluctuates annually with the hydrologic cycle, during low summer flows (base flows) the amount of sediment deposition would be expected to remain relatively constant through time. (For a comprehensive review of the relationship between natural processes and salmonid habitat in western North America, refer to Swanston [1991]).

Forest management implies human activity of various sorts and with varying effects on forest resources. Of particular concern to fish biologists are the effects of ground disturbance from timber harvest, livestock grazing, mining, and the construction and maintenance of roads needed to facilitate these activities. (For comprehensive discussions of the effects of these activities on salmonid habitat in western North America, see Chamberlin *et al*. [1991] [timber harvest], Furniss et al. [1991] [road construction], Nelson et al. [1991] [mining], and Platts [1991] [livestock grazing]). Removal of vegetation, mechanical disturbance, and topographic alteration increase the erodibility of forest soils and, consequently, both the amount of soil available for transport and the likelihood of transport downslope and into streams. Once in streams, fine sediments (i.e., those smaller than 6.3mm in particle diameter) may be transported further downstream or deposited in slow water areas and behind obstructions, locally altering fish habitat conditions. In particular, fine sediment has been shown to fill the interstitial spaces among larger streambed particles, which can eliminate the living space for various microorganisms, aquatic macroinvertebrates, and juvenile fish. Potential problems associated with excessive sediment have long been recognized in a variety of salmonid species and at all life stages, from possible suffocation and entrapment of incubating embryos (see e.g., Coble 1961; Phillips et al. 1975; Hausle and Coble 1976; McCuddin 1977; Cederholm and Salo 1979; Peterson and Metcalfe 1981; Irving and Bjornn 1984; Tagart 1984; Reiser and White 1988), through loss of summer rearing and overwintering cover for juveniles (see e.g, Bjornn et al. 1977; Kelley and Dettman 1980; Hillman et al. 1987; Griffith and Smith 1993), to reduced availability of invertebrate food for resident adults (see e.g., Tebo 1955; Nuttall 1972; Cederholm and Lestelle 1974; Bjornn et al. 1977; Alexander and Hansen 1986). (For a comprehensive review of the habitat requirements of salmonids in western North America, refer to Bjornn and Reiser [1991]).

Since the 1960s, a variety of laws, both state and federal, have been enacted to protect against unmitigated anthropogenic degradation of public resources. With respect to the influences of forest practices on aquatic resources, both NEPA, the National Environmental Policy Act of 1969 (PL 91-190), and NFMA, the National Forest Management Act of 1976 (PL 94-588), require monitoring the habitats of aquatic organisms to help prevent and mitigate anthropogenic degradation. This direction is further embodied in the Payette National Forest Land and Resource Management Plan (Forest Plan), which requires monitoring of both surface and subsurface sediments and establishes criteria within which management activities can occur. Monitoring efforts on the Payette and Boise National Forests actually predate NEPA, where sediment monitoring of subsurface material using core sampling (McNeil 1964) began in 1966 in an effort to assess the magnitude of and trends in sediment deposition on chinook salmon spawning habitat resulting from roads and timber harvest on hillslopes in the South Fork Salmon River (SFSR) watershed; results of early monitoring are documented in several reports and publications (see Nelson et al. 1996 for more information). In recent years, this monitoring has gained importance because of the need to comply with various requirements of the Endangered Species Act (ESA) of 1973 (PL 93-205), as amended, in particular the need to monitor effects of Forest management practices on critical habitat for Snake River spring/summer chinook salmon (*Oncorhynchus tshawytscha*) and Snake River steelhead (*O. mykiss*) as specified in Biological Opinions provided by the relevant regulatory agencies during consultation over new or ongoing Forest actions.

Streambed fine sediments are often divided into a surface and subsurface component, and the two types may affect spawning and rearing habitat differently. Salmonids excavate nests or redds in which to deposit their eggs, and subsurface fines are those that are most likely to directly influence the environment of the incubating eggs. Core sampling provides the most comprehensive look at substrate composition (Chapman and McLeod 1987), and in the SFSR proper (including Johnson Creek) and in the Secesh River system, a major tributary of the SFSR, core sampling remains our principal monitoring technique. Sediment cores have been continuously monitored in these areas since the inception of monitoring studies. The Boise National Forest, with help from the Payette National Forest, samples the main stem of the SFSR and Johnson Creek, and the Payette National Forest samples the Secesh River, a principal tributary of the SFSR. To establish a framework for comparison of trends of subsurface fine sediments revealed by core sampling in these developed watersheds with less disturbed watersheds, core sampling sites were also established in Chamberlain Basin in the Frank Church River of No Return Wilderness (FCRONRW) in 1989.

This report covers analysis of trends in streambed fine sediments derived from core sampling only; trends in surficial and interstitial fine sediments will be examined in a subsequent report. Reports of subsurface sediment trends have been produced periodically since 1976 (Corley 1976), most recently in 1999 (Nelson et al. 1999), and this report builds upon that foundation and is intended to enhance our understanding of streambed responses to natural and anthropogenic influences. Specific objectives for the report include:

- Update analysis of sediment trends derived from core samples taken in the main stem of the upper SFSR to include data collected in 1999 and 2000.
- Update analysis of sediment trends derived from core samples taken from the Secesh River watershed to include data collected in 1999 and 2000.
- Update analysis of sediment trends derived from core samples taken from the Chamberlain Creek watershed to include data collected in 1999 and 2000.
- Compare trends in the non-wilderness upper SFSR and Secesh River watersheds with trends in the wilderness Chamberlain Creek watershed.
- Evaluate quality of the intragravel environment with respect to chinook salmon spawning requirements.
- Disclose and correct identified errors or anomalies in the developing Payette National Forest Fisheries Program database and previous reports.

STUDY AREAS

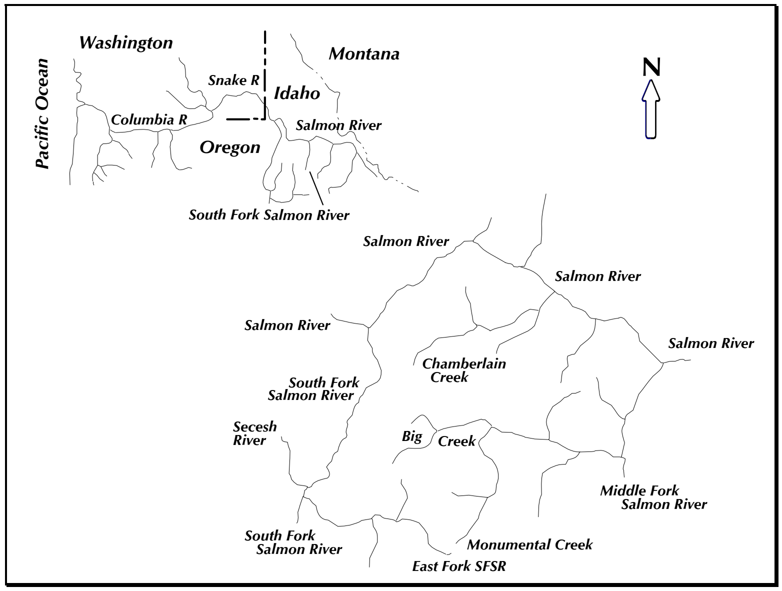

Figure 1.—Relationship of major tributaries of the Salmon River in Central Idaho referenced in this report.

All of the sediment monitoring sites are located on the Payette National Forest, except for two sites on the upper SFSR that are near the northern boundary of the Boise National Forest, and one on Johnson Creek, a principal tributary of the of the East Fork South Fork Salmon River (EFSFSR), also on the Boise National Forest. Monitoring sites in the SFSR watershed have been subjected to a long history of varying resource management, whereas sites in the Chamberlain Creek watershed, a tributary to the Salmon River itself, are in a relatively undeveloped setting. Figure 1 displays the general relationship among streams in the central Idaho mountains.

These streams support dwindling populations of anadromous steelhead (probably *O. m. gairdneri* [Behnke 1992]) and chinook salmon, and important resident species, including westslope cutthroat trout (*O. clarki lewisi*) redband trout (probably *O. mykiss gairdneri* [Behnke 1992]), bull trout (*Salvelinus confluentus*), some of which are also declining in abundance. In fact, several of these species have now been listed under ESA, including designation of critical habitat for anadromous species:

- Snake River spring/summer chinook salmon, listed as *Threatened* (57FR14653).
- Critical habitat for Snake River spring/summer chinook salmon designated (58FR68543).
- Upper Columbia River steelhead, listed as *Threatened* (62FR43937).
- Columbia River bull trout, listed as *Threatened* (63FR31647).
- Critical habitat designated for upper Columbia River steelhead (64FR5740).

PHYSICAL SETTINGS

The major salmon spawning areas in which we've established permanent monitoring sites, are in areas dominated by granitic rocks of the Idaho Batholith, the largest plutonic intrusion in the United States. Soils that result from weathering of this material are generally infertile and lack cohesion. This characteristic, added to the fact that many areas in the central Idaho mountains have very high relief with stream canyons incised deeply with steep walls, leads to high potential for erosion when the lands are disturbed. In contrast, there are some outcroppings of volcanic material at Thunder Mountain and near Stibnite that are more cohesive, erode less readily, and produce smaller diameter particles that quickly leave the system.

Upper South Fork Salmon River

The Upper SFSR, located on the Cascade (Boise National Forest) and Krassel (Payette National Forest) Ranger Districts, is of special concern with respect to anadromous fish because of its high quality habitat (Figure 2) and the fact that it historically hosted the largest runs of spring/summer chinook salmon into Idaho. Currently, the river still supports a diverse and relatively intact assemblage of native fishes, chinook salmon and steelhead returns are clearly depressed. Despite huge reductions in run sizes, both chinook salmon and steelhead continue to spawn in the river's major spawning areas, and hatchery produced salmon are regularly stocked to supplement the natural production.

In 1994, the 18,827ac (7,619ha) Thunderbolt Fire burned on the ridge separating the SFSR from Johnson Creek, and in 2000, another wildfire, the Nick Peak fire, burned about 4,241 ac (1,1717ha) in the Fitsum Creek and Buckhorn Creek watersheds at primarily low to moderate fire intensity levels (Lesch et al. 2000).

For the purposes of this report, we consider the SFSR above its confluence with the Secesh River (Figure 3) to constitute the upper SFSR. Considerable public concern for spawning grounds in the upper SFSR arose in the mid-1960s after extreme weather combined with a history of aggressive watershed development converged to bury them under tons of sediment (see below).

Figure 2.—Upper South Fork Salmon River near the Cascade—Warm Lake Road.

Johnson Creek

Johnson Creek, on the Boise's Cascade Ranger District, is a major tributary of the EFSFSR, which is, in turn, a major tributary of the SFSR (Figure 3). The physical setting of Johnson Creek is similar to that of the upper SFSR, and the two streams flow south to north approximately parallel to one another on opposite sides of an intervening mountain ridge. Johnson Creek supports a similar fish assemblage to the SFSR, and the mass wasting and flooding problems that happened in the upper SFSR in the mid-1960s did not occur on Johnson Creek. In 1994, the 18,827-acre (7, 619ha) Thunderbolt Fire

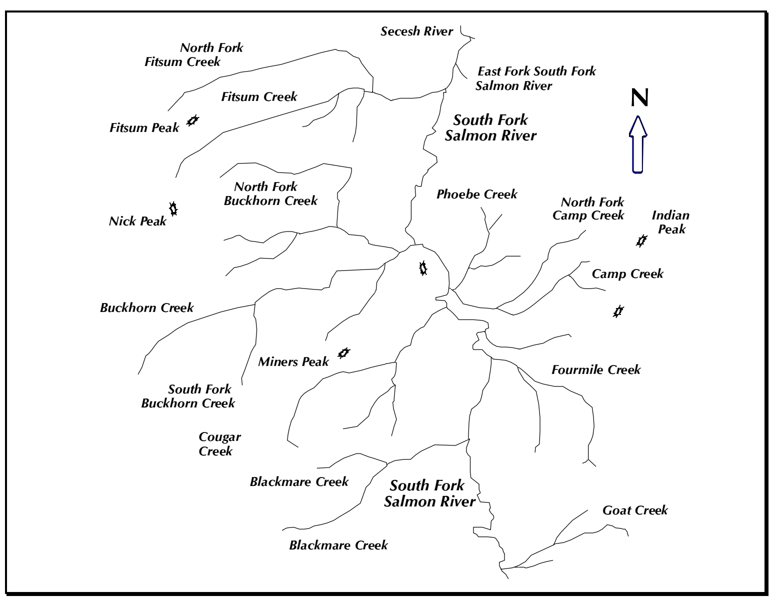

Figure 3.—Significant features of the upper SFSR watershed.

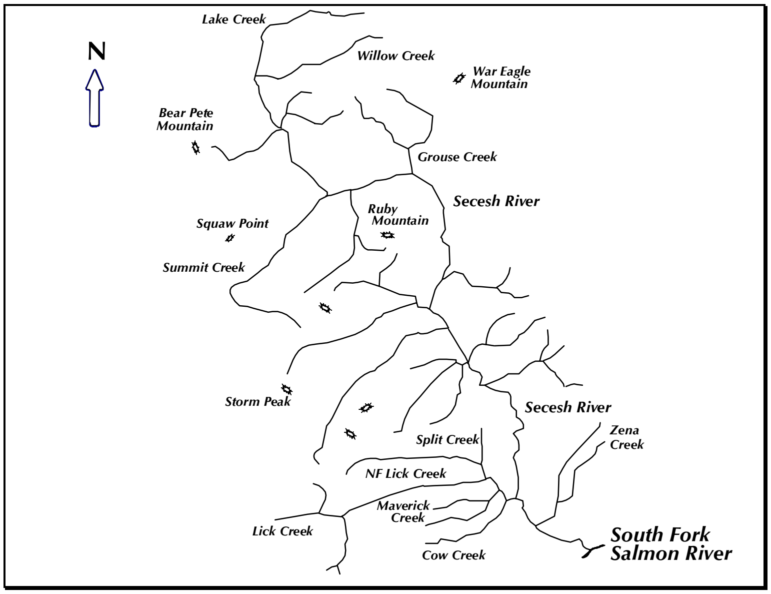

Figure 4.—Significant features of the Secesh River watershed.

burned on the ridge separating the SFSR from Johnson Creek, and emergency rehabilitation efforts were directed at preventing potential erosion problems related to loss of stabilizing vegetation; early in 1996, salvage harvest of timber killed by the Thunderbolt Fire was started.

Secesh River

The Lake Creek-Secesh River watershed is a major tributary of the SFSR, and is located primarily on the McCall and Krassel Ranger Districts of the Payette National Forest. The watershed covers approximately 170,000ac (80,019ha). Like the SFSR watershed, the Secesh River watershed is characterized by the steep slopes and highly erodible granitic soils of the Idaho Batholith; it also supports an assemblage of resident and anadromous fishes similar to that of the SFSR itself. The Secesh River watershed produces a significant portion of the wild anadromous fish produced in the entire SFSR drainage. Redd counts made on this drainage by the Idaho Department of Fish and Game and reported by Horner and Bjornn (1981) and Pollard (1984) have averaged between 10 and 20% of the total SFSR counts; however, runs in the Secesh River system have received no supplementation with hatchery-produced fish, and are therefore extremely important for preservation of the indigenous gene pool.

The major chinook spawning areas are found in the upper reaches of the Secesh River drainage beginning about 16mi (26km) upstream from the confluence with the SFSR (Figure 4). These reaches include the low gradient areas of Secesh Meadows downstream to the Chinook Campground, the lower reaches of Summit and Grouse creeks, and the low gradient areas along Lake Creek. They are characterized by broad meadows surrounded by only moderately steep mountain slopes; flash floods and mass land failures are rare occurrences due to the fairly high elevations (between 5,650ft [1,725m] and 6,400ft [1,950m]) and low gradients, and sediment delivery to the streams in this area is generally low. The topography of the Secesh River watershed is more moderate than that of the upper SFSR, and, although some areas suffered extensive hillslope failures, the floods of 1964-1965 that inundated the upper SFSR with fine sediment had a lesser effect on the principal Secesh River and Lake Creek spawning areas. Consequently, spawning habitat in most areas remained in relatively good condition (Chrostowski 1976; Burns 1978; Lund 1982,1984,1985).

In 1994, the Corral Fire burned on hillsides adjacent to Lake Creek in the vicinity of known chinook spawning areas, but no rehabilitation efforts were initiated to prevent possible increases in sediment from loss of stabilizing vegetation because the threat was considered to be minimal (Zuniga et al. 1994). In 2000, the Burgdorf Junction Fire started on a hillside above Burgdorf and burned through the Grouse Creek, Flat Creek, and Piah Creek watersheds. In the Flat Creek and Grouse Creek watersheds, nearly all the trees were killed except for those in the Sand Creek watershed, a tributary to Grouse Creek (Figure 5). These were three of the most extensively burned watersheds in the fire (Zuniga et al. 2000).

Chamberlain Basin

The Chamberlain Basin is on the Payette's Krassel Ranger District and contains streams tributary to the Salmon River, which it joins at approximately 45°26' north latitude and 114°56' west longitude in the FCRONRW near the northeastern boundary of the Payette National Forest (Figure 6). Geologically, the watershed area that influences the monitoring sites is dominated by granitic rocks of the Idaho Batholith, with Quaternary alluvial deposits in valley bottoms. Pleistocene glaciation was the overriding geomorphic force responsible for sculpting the landscape. The basin supports a fish assemblage similar to that of the SFSR, but has not experienced outplanting of hatchery-produced chinook salmon.

Figure 5.—Aerial view over the Flat Creek and Grouse Creek watersheds during the Burgdorf Junction Fire, September, 2000.

Much of the Chamberlain Creek watershed upstream of Chamberlain Guard Station burned during the 1994 Chicken Peak Fire, and most of the rest of the watershed burned during the Flossie Fire in 2000. Both of these fires comprised primarily low and moderate intensity fire, with some patches of high intensity (Gerhardt et al. 1994; Kennell et al. 2000).

CULTURAL SETTINGS

The central Idaho mountains have a rich cultural background. Before the arrival of settlers of European ancestry, and possibly dating back as far as 10,000 years, the major river valleys provided camping areas, travel ways, and fishing grounds for several American Indian tribes, including the Nez Perce, Shoshone, Bannock, and Sheepeater. No reservations exist on the Forest, but several tribes, including the Nez Perce, Shoshone, and Bannock, have treaty rights that include hunting and fishing in traditional areas.

Settlers of European ancestry made their way into the area in the early 1800s. These early settlers were primarily trappers and miners, and during the height of the mining activity, Chinese laborers also appeared. Early timber harvest was primarily for local

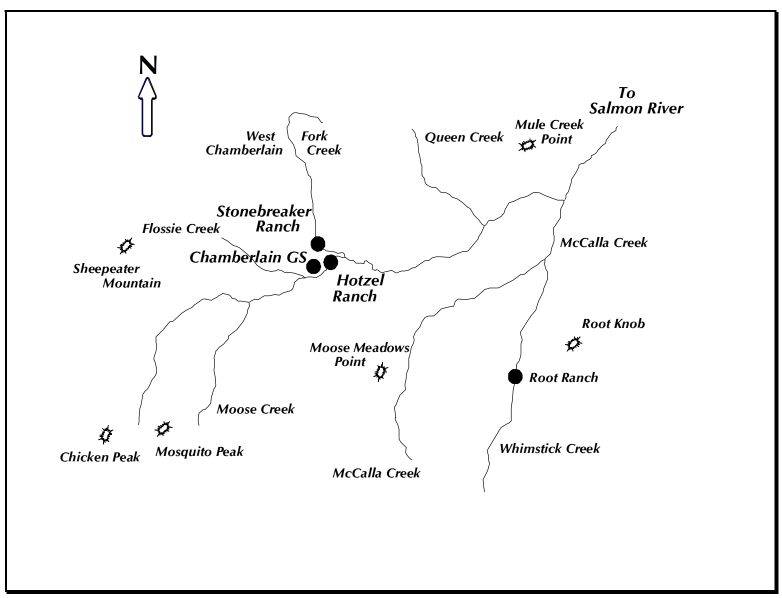

Figure 6.—Significant features of the Chamberlain Creek watershed.

mining camps and other settlements, and, since the early 1900s, timber production has been an important aspect of forest management. In the mid-1980s, the Payette National Forest produced about 65 million board feet (MMBF) annually, but public concerns over possible damage to fish and wildlife habitat from logging operations have resulted in reductions in timber sales in the last decade two decades.

Anadromous fish in the Columbia Basin are biologically, economically, and spiritually important, but they face a variety of challenges; consequently, many local populations are at risk of extinction. Because of the interaction of individual factors and the accumulation over time of additive or multiplicative threats to their continued survival, populations of anadromous fish are generally on the decline throughout the Salmon River system. In Idaho, anadromous fish produced in the Salmon River and its tributaries must navigate some 600mi (965km) from the gravels in which they hatched to the mouth of the Columbia River, drifting through or being transported around eight large dams with their spillways, turbines, and sluggish flows, predatory fish and birds, and other threats associated with outmigration over such an extended course. At sea, the maturing fish face natural threats as well as commercial and recreational harvest before they begin their return to natal gravels. During their spawning migration as adults, they must again pass the eight Columbia River and lower Snake River dams while surviving tribal, commercial, and recreational river fisheries. Because of high mortality during spawning and outmigrations, spawning conditions and survival during early rearing life stages assume greater significance.

Upper South Fork Salmon River

Timber production gained prominence in the early 1900s, and reached a peak in the middle of the century. Between 1950 and 1965, the upper SFSR watershed was subjected to a great deal of timber harvest and road construction on highly erodible lands; about 622mi (1,000km) of road were constructed in the watershed during this period, and sediment yield increased accordingly (Arnold and Lundeen 1968; Megahan et al. 1992). By 1962, the SFSR and its tributaries continued to provide good fish habitat, but increasing siltation was noted (Whitt, 1962); it was later estimated that erosion rates in the mid-1960s were about 350% above natural rates (Arnold and Lundeen 1968). Then, late in 1964 and in the spring of 1965, intense storm events and the resulting runoff literally inundated the SFSR with sediment that blanketed the streambed and covered many important spawning and rearing areas used by anadromous fish (Figure 7). Timber harvest was suspended in the watershed in 1965, pending restoration of streambed conditions, although some limited logging was permitted in the early-1980s and in the 1990s following the 1994 wildfires. Many roads, including system, non-system, and rehabilitated continue to provide sediment to the river. In 1994 the main SFSR Road, which parallels the river and is often adjacent to it, was paved in an effort to remove an obvious source of material, but short term effects of road reconstruction are unclear. The long-term effects, which should include a reduction in streambed fines, will take some time to be realized as the cut and fill

Figure 7.— Surficial deposits of fine sediments in Krassel Hole, 1966.

slopes stabilize, a process that has been somewhat retarded because of extensive flooding in 1996-97 and 1997-98; in fact, the latter of these two was probably quite similar to the 1964-65 'Christmas Floods' (Nelson et al. (1998).

In recent years, recreational fishing for surplus hatchery production of chinook has been open in the upper SFSR upstream from Goat Creek, and Nez Perce and Shoshone-Bannock tribal fishing continues as well.

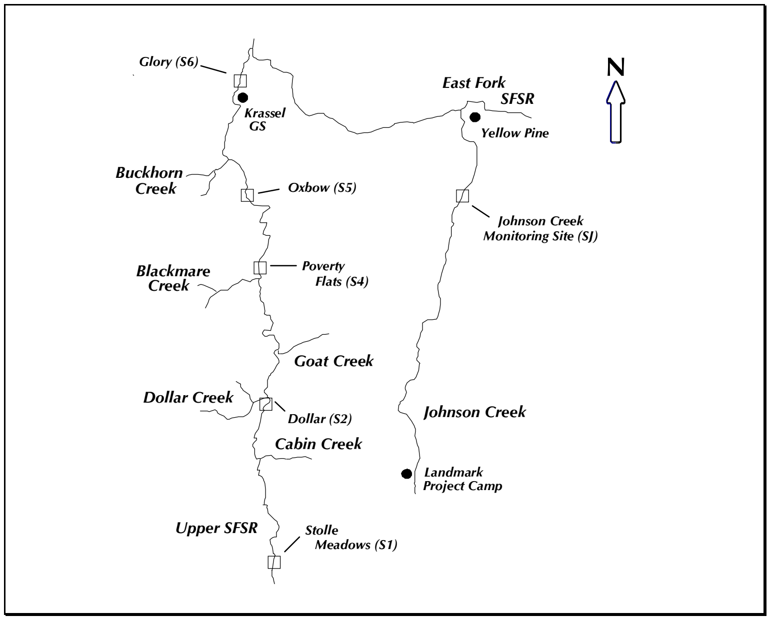

Figure 8.—Core sampling locations in the upper SFSR and Johnson Creek (site identification codes are those used by the Boise National Forest; see text for Payette equivalents).

Monitoring of sediments in the SFSR has been pursued since 1966. These efforts showed a rapid initial build-up and then attenuation of fine sediments (Megahan et al. 1980), followed shortly by a more gradual decline (Platts et al. 1989). Now, subsurface fine sediments are thought to be fluctuating about a newly-established, post-disturbance equilibrium (Megahan et al. 1992), a contention that our recents reports generally support (Nelson et al. 1996,1997,1998). Although timber harvest has largely been avoided in the SFSR, the Payette and Boise National Forests' Land and Resource Management Plans indicate that renewed harvest is an option. Continued monitoring is needed to determine whether ongoing and proposed activities are appropriate and whether mitigation measures have been successful.

The current sampling protocol in the upper SFSR includes sediment core sampling in spawning areas at Stolle Meadows (B081), Dollar Creek (B082), near the mouth of Dollar Creek, Poverty Flat (E083), the Oxbow (E084), adjacent to the Reed Ranch, and Glory Hole (E085), near the Krassel Guard Station (Figure 8).

Johnson Creek

Johnson Creek is wholly administered by the Boise National Forest, and has been managed much as has the Upper SFSR. The headwaters areas have historically been used for both timber harvest and livestock grazing, but the problems that occurred as a result of the 'Christmas Storms' of 1964-65 did not result in massive inundation of the spawning areas on Johnson Creek. For this reason, a core sampling site (B152) was established on Johnson Creek near Ice Hole on lower Johnson Creek (Figure 8) as a control site for the SFSR sites that is subject to similar forest management.

Secesh River

The history of the Secesh River area is somewhat sketchy. Hillsides and valleys in the area have been subjected to a variety of land use activities, including livestock grazing, mining, and timber harvest, but these have been considerably reduced in recent years. A road from Riggins passed through the Burgdorf area prior to 1894 to provide access to the mining camps in the Warren area; access from McCall apparently came a decade or two later (Hockaday 1968). Cattle were brought in first to feed the miners in the Warren area, and being grazed in the Burgdorf area by 1870 (USFS 1995). Sheep appeared later, probably in the late 1800s or very early 1900s (USFS 1995), and are the only livestock class permitted now.

The Secesh River watershed is in the Resort Mining District (USBM 1995). Gold was probably discovered in the early 1860s (Ross 1963), and mining, which peaked sometime between 1880 to 1912,has been an important activity since about 1870 (Capps 1940). Gold-bearing placers occur in the alluvial deposits of the stream valleys, and dredging has been common. Some deposits are also on stream terraces in moraines, where some hydraulic mining has also been used (Capps 1940). Most of the deposits were of relatively low value, but there have been significant mining operations on Grouse Creek, in the Secesh Meadows area, in the Ruby Meadows area on Ruby Creek, and along Lake Creek and Threemile Creek (Lorain and Metzger 1938; Capps 1940). Little mining occurs at present, and several mines, including the large Golden Rule mine on Grouse Creek, have been reclaimed (Lund and Burns 1993a).

Figure 9.—Collapsed logging road in the Zena Creek watershed, 1965.

In order to mitigate watershed degradation resulting from this history of use, the current Forest Plan (USFS 1988) specified various habitat restoration activities, including realignment of the Lake Creek road near Burgdorf.

Core sampling locations were established in 1981 in five important spawning areas for anadromous fish in the Secesh River watershed: Corduroy Junction (E034), Threemile Creek (E033), Burgdorf (E048),

Timber harvest has also been important in the Secesh River watershed, but most recent harvest has been restricted to posts and poles, house logs, and other ‘miscellaneous forest products’ (Lund and Burns 1993b). In the early 1960s, however, a large administrative research study was implemented in the Zena Creek watershed that culminated in the harvest of about 60 MMBF of timber (Hockaday 1968). The ‘Chistmas Storms’ of 1964-65 did not affect the Secesh River watershed to the extent that they did the upper SFSR, but there were hillslope failures in the Zena Creek watershed (Figure 9).

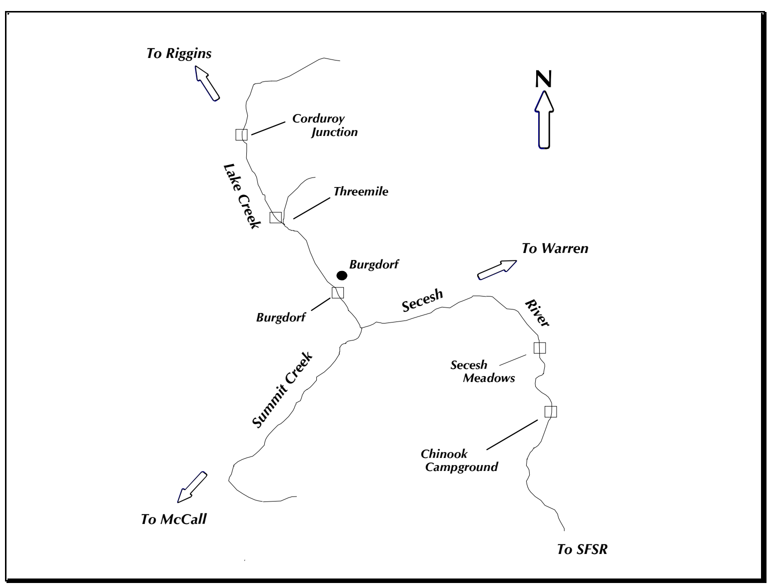

Figure 10.—Core sampling locations in the Secesh River watershed.

Secesh Meadows (E096), and near Chinook Campground (E046) (Figure 10). These sites have been sampled annually since that time, except for 1988.

Following extensive fire in 1994, no emergency rehabilitation efforts were deemed necessary (Zuniga et al. 1994). Following the Burgdorf Junction Fire of 2000, which caused considerable tree mortality in the Grouse Creek watershed, some important emergency actions were identified. An old road along Grouse Creek was identified as a potential threat to listed fishes in Grouse Creek and a potential source of excess sediment to spawning areas in the Secesh River if above-normal water yield and flooding occurred as a result of the loss of trees in the watershed, and is being modified to protect aquatic resources (Zuniga et al. 2000).

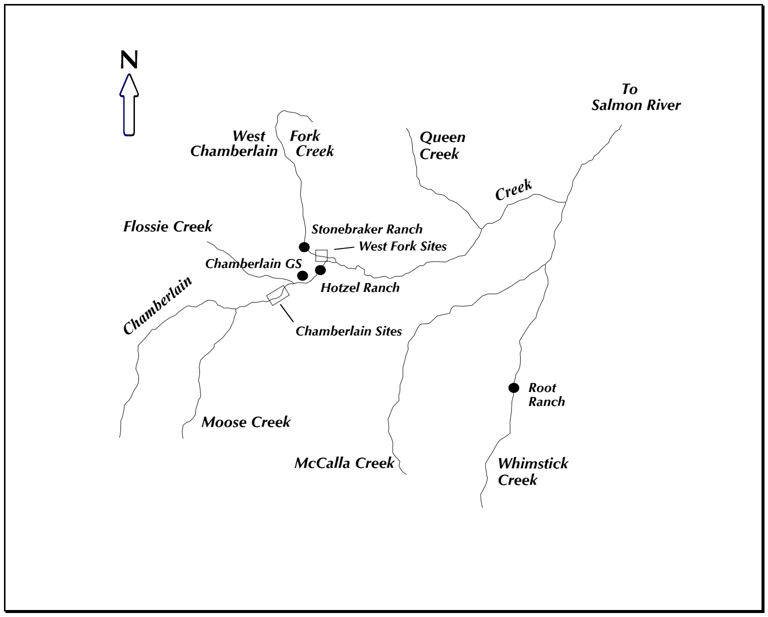

Figure 11.—Diagram of the Chamberlain Creek watershed showing principal tributaries and locations of core sampling sites.

Chamberlain Basin

The Chamberlain Basin supports a fish assemblage similar to that of the SFSR, but has not experienced outplanting of hatchery-produced chinook salmon. No recent resource development has occurred in the drainage, though two large stock ranches in the basin were active in the early 1900s (Jones 1989). Significant recent impacts include primarily recreational use, including incidental grazing by pack animals, and the watershed of the West Fork has received some relatively recent domestic grazing use that resulted in visible streambank damage (D. Burns, personal observation). In 1994, the Chicken Peak fire burned hillsides flanking Chamberlain Creek, but the wilderness setting, lack of threat to property, and desire to maintain natural ecosystem processes precluded rehabilitation efforts in the drainage.

Core sampling was first performed on Chamberlain Creek in 1981, but was not resumed until 1989, when sites where the one spawning area on Chamberlain Creek was revisited (E032) and another site was established on a spawning area on West Fork Chamberlain Creek (E136). The site on Chamberlain Creek is downstream of the confluence of Flossie Creek; the one on West Fork of Chamberlain Creek is downstream of the Stonebreaker Ranch (Figure 11). Because of its largely undeveloped setting in a geology that is similar to the SFSR sites, these sites serve as nearly true controls.

Methods

Core Sampling

Subsurface sediment was sampled using a hollow-core procedure (Figure 12) similar to the method described by McNeil (1964). The Payette and Boise National Forests are each responsible for part of the subsurface monitoring that is done in streams of the SFSR watershed, and each uses slightly different, though generally compatible, field procedures and sieve sizes (see Nelson et al. 1996, 1997, 1998 for details). (Although both English and metric sizes have been used so far, further discussions of particles and sieve sizes will be restricted to the metric value because they are most familiar in this context). In addition, the Payette National Forest protocol called for a change in sieve sizes beginning in 1983 (Lund 1984), as well as a slight change in how the fraction passing through the finest mesh sieve was handled. (This conclusion is inferred from the method descriptions in Lund [1984]).

Figure 12.—Core sampling on the South Fork Salmon River, 1998.

Procedures used by the Payette National Forest have been described in detail by Lund (1981, 1984, 1985). Generally, 40 samples (in some cases, the number may differ for various, non-systematic reasons) were collected using a 12-in (30.4-cm) diameter core, worked into the gravel to a depth of approximately 10in (25cm) at randomly selected locations within a specified stream reach that was a known chinook salmon spawning area and that could be monitored annually; reaches may have been further stratified into sub-reaches or sub-stations if needed to collect 40 cores. Individual sampling locations were randomly selected from a rectangular grid superimposed on the reach. Approximately 2.1gal to 2.6gal (8l to 10l) of streambed material were excavated from within the area defined by the core sampler. Sediment samples were then strained through sieves of decreasing mesh size and drained to remove excess water, with the amount of sediment retained in each sieve determined on-site by the volume of water it displaced. Removed sediment was returned to the streambed in the hole from which it was excavated.

Procedures used by the Boise National Forest are described in detail in Newberry and Corley (1984), and are very similar to those used by the Payette National Forest. Principal differences included choice of sieve sizes (see Nelson et al. 1997 for details), sediment was not replaced in the hole excavated in the streambed (and possibly not even to the streambed), there was excavation of a slightly larger volume of sediment (up to 3.1gal [11.8l]) (Dale Olson, Fisheries Biologist, formerly Boise National Forest, Cascade, ID, personal communication), and sites have been standardized with four sub-stations at each spawning area except Stolle Meadows, which has eight. The two methods have been compared with data from the Poverty spawning area in the SFSR, and no statistically significant differences in results were detected (Newberry 1988). In addition, the Boise National Forest added a 9.5mm sieve to their sampling protocol in 1997 to allow intragravel quality analysis.

Statistical Analysis

Basic Calculations

Core sample data were entered as the total volume of sediment retained in sieves of various standardized mesh sizes. Although the Boise National Forest and Payette National Forest sediment monitoring programs use sieves of different sizes, the three sizes corresponding to the most frequently used sediment particle diameters referred to as 'fines' (6.3mm, 4.75mm, and 0.85mm)[1] have been used by both forests. Sediment passing these three sieves were referred to as fines smaller than 6.3mm ('large fines' or 'fines'), fines smaller than 4.75mm ('coarse fines' or 'sand'), and fines smaller than 0.85mm ('small fines' or 'silt'), and are calculated as a proportion of the total volume of sediment.

Although simple evaluation of the proportion of fine sediments of a given size class in the streambed is adequate for monitoring trends, it does not effectively address the structure of the intragravel environment. Another statistic, geometric mean particle diameter, incorporates information about the distribution of particle sizes in the sample and has been used to circumvent this shortcoming (Platts et al. 1979; Shirazi and Seim 1979). Geometric mean particle diameter was calculated from core sampling data as:

$$d_g = (d_1\hat{\ }v_1)*(d_2\hat{\ }v_2)*...*(d_n\hat{\ }v_n) \qquad (1)$$

where 'd_n' was the arithmetic midpoint diameter of particles retained by sieve 'n', 'v' was the decimal fraction by volume of the sediment fraction retained by the sieve, '*' denotes multiplication, and '^' denotes exponentiation. Shirazi and Seim (1979) used dry weight in this formula rather than volume. Dry weights are undoubtedly more accurate because no water is retained in the sample, a problem that may be more serious in calculation of geometric mean than simple proportions of fines. Core sampling using dry weight is too labor-intensive for routine field monitoring, so volume displaced by the sediment fraction retained by each sieve was used. To compensate for retained water, correction factors as suggested by Platts et al. (1983) were applied to the sieve fractions before calculation of geometric mean particle diameter. We do not know the density of our samples, so we used the intermediate factor presented in Platts et al. (1983) for a density of 2.6. We believe that this approach will still yield an acceptably accurate estimate of geometric mean particle diameter for time series analysis. There is no theoretical upper limit to the maximum particle diameter needed to calculate d_1 because extremely large pieces are often sorted manually rather than being sieved; for convenience, we have used the McNeil sampler's diameter (12in [304.8mm]) to define our upper limit.

As with percent fines, some workers have questioned the utility of evaluating spawning gravels with geometric mean particle diameter. Platts et al. (1983)[2] state that geometric mean particle diameter may be relatively insensitive to management-induced changes in streambed condition; in addition, Platts et al. (1983) and Tappel and Bjornn (1983) indicate that streambed mixtures of different classes of fine sediments and of potentially different 'quality' with respect to the needs of developing trout and salmon embryos, may have the same geometric mean diameter. To overcome these possible difficulties, Tappel and Bjornn (1983) proposed a graphical method of determining quality for salmonid spawning gravels using the ratio of particles smaller than 9.5mm ('pea-gravel') and fines smaller than 0.85mm in diameter ('silt'). Their method relies on the fact that core sampling in the South Fork Salmon River, Idaho, and the Clearwater River, Washington, indicated that streambed particles smaller than 25.4mm and 26.9mm in diameter, respectively, were lognormally distributed so that cumulative frequencies plotted as straight lines on log-probability paper. Further investigation of the South Fork Salmon River cores showed that a line passing through data points for the 9.5mm

[1] These sizes have been variously indicated on data sheets, and in procedural guides and reports as 6.33mm and 6.3mm, 4.75mm, 4.74mm, and 4mm, and 0.85mm and 850μm, respectively; any actual but trivial size differences at this scale have been ignored.

[2] This was cited as Beschta (in press), which was published in 1982 and was cited Beschta (1982) in our previous reports prior to 1999; however, we have been unable to locate that document for this report.

and 0.85mm particles closely approximated the regression model produced for particles smaller than 25.4mm. A benefit of this approach is that core samples with identical geometric mean diameters, but different substrate mixtures, plot into different portions of a graph with axes defined by the proportion of fines smaller than 9.5mm and 0.85mm.

Tappel and Bjornn (1983) took this a step further by evaluating survival of eyed chinook salmon and steelhead eggs in varying gravel mixtures. Survival tests plotted on graphs with axes defined by the proportion of fines smaller than 9.5mm and 0.85mm showed reasonable agreement with empirically derived survival functions. The survival function developed for chinook salmon was:

$$S=93.4-(0.171p_{9.5}p_{0.85})+3.87*p_{9.5} \quad (2)$$

where 'S' is survival (in percent) and '$p_{9.5}$' and '$p_{0.85}$' are the relative proportions (in percent) of particles smaller than 9.5mm and 0.85mm in diameter, respectively.

We used this approach to model the approximate quality of spawning gravels by plotting core sample means (for a given year) on axes defined by the proportion of fines smaller than 9.5mm and 0.85mm, and by overlaying the survival curves ('isolines') representing 80% and 60%. These represent overestimates of survival because Tappel and Bjornn (1983) used eyed eggs in their study, and green eggs spawned in the wild will undoubtedly suffer higher mortality. In a relative sense, however, this appears to be a very useful approach to understanding both sediment trends and apparent quality as spawning gravel. Before 1998, we were only able to apply this method to sites on the Payette National Forest, as the SFSR and Johnson Creek samples did not include a 9.5mm sieve; the Boise National Forest added this sieve in 1997.

Time Trends

We had 24 years of data for time series analysis in the SFSR, 18 years in the Secesh River, and 12 years in the Chamberlain Basin. We looked for trends in intragravel conditions using ordinary least squares (OLS) linear and autoregressive regression (autoregression). The autoregressive technique is preferable because values in a time series typically violate the assumption of independence because of serial autocorrelation. In a time series with positive autocorrelation, OLS regression may underestimate the residual variance, increasing the likelihood of detecting a trend that does not exist (Gerrodette 1987). The SAS® 8.x[3] autoregression procedure (PROC AUTOREG) produces regression parameters for each model and calculates the Durbin-Watson statistic (DW) to test for autocorrelation. Significant trends were those in which the slope (represented in the results tables as ***b***) was significantly different than zero (H_o:b=0) at a probability level of 10% (α = 0.10)[4].

Interbasin Comparisons

Two approaches were used to look at differences in spawning conditions among the three watersheds. The first was a simple multiple comparison of means (pooled for all sites) by year using the SAS® 8.x general linear model procedure (PROC GLM) with Tukey's Honestly Significance (HSD) test and α=0.10. The HSD test was selected because it has better control over the Type I error than other commonly applied tests (e.g., Fisher's LSD and Duncan's Multiple Range Test).

Streamflow

Discharge data for the SFSR are incomplete and were not measured before 1965. We have used the complete record from the stream gage at Yellow Pine, Idaho, on nearby Johnson Creek (JOHN in Equation 3) to fill in the gaps in the SFSR record. Johnson Creek parallels the SFSR and its flows are highly correlated with those of the SFSR. We used all mean annual discharge data that both sites had in common to

3 The use of trade, firm, or corporation names in this publication is for the information and convenience of the reader, and does not constitute an official endorsement or approval by the U.S. Department of Agriculture of any product or service to the exclusion of others that may be suitable.

4 Rounding of slopes and intercepts (***a***) has been performed to the nearest tenth. In some cases this may result in a significant slope represented as ±0.0; the significance in this case is based on decimal values that have not been displayed.

calculate a linear regression model to predict the mean annual discharge value for the missing years. The resulting model was:

$$Q_{SFSR} = 1.6095Q_{JOHN}-21.4452 \qquad (3)$$

where 'Q' is discharge in feet per second (fps). This model was built with 25 observations and had a coefficient of determination (**r^2**) of 0.93. Discharge data were taken from the USGS water resources data books for Idaho when available, or from daily flow data posted on the USGS Water Resources historical flow data web page (http://www.usgs.gov/nwis-w/).

Graphics

With the exception of the snow-water equivalent graph in Figure 29, which was downloaded from the USDA Natural Resources Conservation Service (NRCS) SNOTEL worldwide web site (http://www.wrcc.dri.edu/snotel.html), all graphs were produced using the PC SAS® 6.12 graphics procedure PROC GPLOT.

Quality Assurance and Quality Control

Core sampling data are obtained from the districts responsible for data collection. The Krassel Ranger District is the responsible party on the Payette National Forest, and they use a data entry program specifically developed to allow incorporation of these data into the PNF Fisheries Program's permanent database; specific protocols have been established for data entry and verification. For data collected by the Boise National Forest, we have obtained electronic spreadsheets containing the data as entered by their personnel, and we assumed that it was accurate. Where possible, numeric results were checked against the same values in other reports (this was especially important in the early stages of database development).

Over the years, there have been some minor adjustments in the precise locations from which samples were taken, but they have remained in the same general location. We feel certain that no changes have been made that would preclude the generation of realistic time trends.

It should also be understood that this report is the latest in a series of reports that not only report on our sediment monitoring, but reflect the progress of our database development. As such, there have been and probably continue to be cases where corrections to the database are reflected in the results. These seldom lead to changes in interpretation, but may lead to inconsistencies in tabulated results from year to year. In addition, we expect to uncover data irregularities over time. One such instance occurred this year when we discovered that 1989 and 1990 data for West Fork Chamberlain Creek were incorrect because of a torn sieve; we have retained the data but excluded it from the analyses discussed in this report.

Results and Discussion

Upper South Fork Salmon River

Time Series Analysis

In general, fine sediments, as estimated by core sampling, appeared to generally increase slightly in 1999, followed by a decline in 2000 (Table 1). However, the Dollar site had very high fines in 1998, followed by declines in both 1999 and 2000, and fines at Glory Hole declined in both 1999 and 2000winter . The winters of 1996-97 through 1998-99 had unusually high flow events, including a mid-winter rain on snow event in 1997 that was similar to the 1964-65 winter event that led to concern over spawning habitat in the SFSR (Nelson et al. 1998). On the other hand, the winter snowpack in 2000 was near normal, there were no flood events, and runoff peaked relatively early in the spring.

Stolle Meadows.—The Stolle Meadows spawning area is the farthest upstream of the sediment monitoring areas, where the SFSR is primarily a meandering meadow stream. Because this area is at fairly high elevation and above the narrow, steep-walled canyon portion of the SFSR, it was spared much of the disruption that was associated with the floods of 1964 and 1965. Large (<6.33mm) and coarse (<4.75mm) fines are increasing gradually in this area, whereas the very smallest fines (<0.85mm) are remaining relatively stable over time (Table 2, Figure 13). The corresponding increasing trend in geometric mean particle diameter indicates that the streambed is gradually coarsening. Nelson et al. (1999) suggested that the scatter of points at that time might be indicating that levels of large fine sediments began to decline in 1991, with some rebounded from 1994 through 1998. This led to the largest amount of large fines on record in 1996. Since 1996, large fines have remained below 1996 levels, but the increasing trend continues. It

Table 1.—Mean annual levels[a] of subsurface fines (in percent) and geometric mean particle diameters from core sampling in monitoring sites in the South Fork Salmon River watershed above the confluence with the Secesh River, 1977-2000.

	Stolle Meadows (B081)				Dollar (B082)				Poverty Flat (E084)			
Year	**LF**	**CF**	**SF**	**GM**	**LF**	**CF**	**SF**	**GM**	**LF**	**CF**	**SF**	**GM**
1977	22.2	18.5	4.5	19.2	29.0	25.6	5.5	15.8	35.9	31.3	13.2	11.9
1978	19.9	17.1	5.8	20.3	31.1	27.8	6.7	14.7	33.7	29.2	11.1	12.5
1979	23.0	19.2	6.4	19.1	28.1	25.3	8.5	16.0	32.4	28.9	11.8	13.6
1980	20.7	16.2	3.6	44.8	27.7	24.3	4.9	28.3	29.3	26.4	6.0	23.2
1981	22.7	18.0	5.3	38.1	26.2	22.6	7.0	30.9	30.1	26.6	8.7	23.7
1982	17.5	14.0	4.5	48.4	27.5	23.8	6.3	29.2	30.4	26.7	7.5	23.1
1983	22.4	18.8	4.7	35.9	27.8	24.5	4.1	30.3	35.5	31.5	5.5	17.8
1984	25.0	20.8	4.4	29.9	26.5	23.0	3.6	29.1	28.9	25.3	4.7	25.2
1985	22.7	18.8	4.5	33.6	29.7	26.1	4.3	25.0	36.0	32.3	5.5	17.9
1986	26.3	21.5	5.4	31.3	28.7	24.4	4.5	28.2	34.1	29.4	6.0	22.0
1987	27.0	21.5	5.1	35.1	28.6	24.3	4.1	30.0	33.8	28.6	7.5	18.4
1988	20.4	16.3	4.1	45.1	26.8	22.3	4.2	29.6	30.2	25.2	4.7	26.6
1989	22.7	17.9	4.6	39.0	30.9	26.7	4.0	25.5	28.3	24.3	4.4	27.3
1990	25.8	20.7	5.5	32.6	30.2	24.7	4.7	23.2	29.8	25.5	5.4	25.2
1991	26.2	21.0	5.0	35.1	26.6	21.8	3.3	29.2	31.2	26.9	4.8	23.6
1992	24.5	20.4	5.1	37.9	26.4	22.8	4.0	31.0	31.2	27.1	7.4	22.1
1993	23.4	19.0	4.6	36.5	29.5	24.6	4.1	26.9	35.1	30.7	5.5	18.6
1994	18.9	13.4	2.7	54.1	26.0	19.9	2.5	39.6	33.4	26.2	4.3	25.5
1995	26.7	21.8	5.9	28.2	25.6	21.5	4.6	29.6	29.8	25.5	5.9	25.0
1996	32.8	28.1	6.0	25.8	27.8	23.9	5.3	28.3	35.3	29.7	5.9	18.2
1997	25.5	20.4	5.6	35.6	28.9	23.8	4.6	26.3	36.8	31.7	9.0	18.3
1998	24.3	19.7	5.4	36.7	42.7	37.2	9.6	15.6	28.0	23.4	4.2	26.6
1999	28.6	24.3	5.3	30.0	26.3	22.0	3.7	28.6	37.8	31.6	7.8	17.7
2000	25.2	19.4	4.1	33.3	28.9	24.1	1.9	26.1	30.1	26.1	2.4	35.7
Mean	***23.9***	***19.5***	***4.9***	***34.4***	***28.6***	***24.5***	***4.8***	***26.5***	***32.4***	***27.9***	***6.6***	***21.7***
	Glory Hole (E085)				**Oxbow (E083)**				**Ice Hole (B152)**			
Year	**LF**	**CF**	**SF**	**GM**	**LF**	**CF**	**SF**	**GM**	**LF**	**CF**	**SF**	**GM**
1977	31.8	28.0	7.0	13.6	35.0	31.4	7.3	12.7	24.4	21.8	4.8	17.2
1978	31.7	28.4	11.0	13.2	36.4	32.7	11.6	11.8	25.5	23.1	6.5	16.4
1979	32.8	28.8	6.1	14.1	34.9	31.2	10.1	12.7	23.1	19.5	6.0	18.3
1980	30.6	25.0	6.1	23.9	32.0	27.7	7.2	22.0	25.4	22.3	5.5	29.5
1981	27.2	24.1	5.0	25.2	31.4	27.5	8.3	22.0	25.9	22.8	4.6	26.3
1982	24.5	20.7	5.2	28.5	30.5	26.8	6.8	24.1	27.3	24.4	4.7	25.4
1983	24.5	21.4	4.2	30.1	36.2	31.9	6.3	19.0	27.9	24.9	4.2	25.5
1984	22.1	19.1	3.1	33.7	33.5	29.4	5.0	20.0	27.9	25.0	3.3	23.7
1985	28.9	25.8	4.0	25.8	36.6	32.4	5.4	17.0	32.3	29.4	3.6	20.7
1986	22.5	19.1	3.2	34.0	35.6	29.8	5.7	18.3	31.6	28.4	4.2	21.5
1987	28.8	24.2	5.2	25.6	35.5	30.3	6.6	18.8	27.9	24.6	5.2	26.7
1988	25.2	21.7	3.8	31.1	29.7	24.6	4.4	25.4	26.1	22.7	4.8	31.7
1989	24.1	19.6	3.7	30.0	30.0	24.9	5.2	25.6	25.7	21.9	4.2	28.5
1990	28.6	24.9	3.5	25.9	31.7	26.2	5.5	23.2	23.7	20.9	3.4	29.9
1991	23.6	19.9	3.8	31.8	27.1	21.9	4.6	26.6	28.3	25.1	4.3	26.9
1992	27.4	24.0	5.2	28.1	28.3	23.7	5.9	27.8	26.2	23.4	3.5	32.5
1993	22.8	18.8	3.8	32.4	21.8	16.7	3.4	38.0	30.4	26.2	4.2	23.4
1994	22.5	17.2	1.5	41.8	33.2	24.3	3.0	26.4	30.7	26.8	2.9	28.0
1995	34.9	30.7	5.1	17.5	34.1	27.4	6.1	19.5	33.3	29.2	5.4	18.8
1996	34.3	30.3	5.8	20.0	32.2	26.7	5.9	22.2	28.5	24.3	3.7	29.5
1997	34.2	29.2	5.9	19.6	36.3	31.6	7.6	17.1	27.8	23.6	5.3	26.1
1998	38.7	33.4	7.2	16.8	29.2	23.2	5.9	23.6	26.9	22.9	5.6	27.5
1999	35.2	30.7	6.5	18.9	31.3	25.6	6.8	22.2	26.9	23.0	4.6	27.4
2000	29.2	24.7	2.6	25.9	27.9	21.7	3.6	25.0	23.0	19.2	3.5	40.8
Mean	***28.6***	***24.6***	***4.9***	***25.3***	***32.1***	***27.1***	***6.2***	***21.7***	***27.4***	***24.0***	***4.5***	***25.9***

[a]LF = large fines; CF = coarse fines; SF = small fines; GM = geometric mean particle diameter. (NOTE: This table in Nelson et al. [1998] the Oxbow had coarse fines as 32.6 in 1997 and for Dollar had large fines as 21.6 in 1995; these were apparently typographic errors).

Table 2.—Regression parameter estimates for fine sediments and geometric mean particle diameter, Stolle Meadows spawning area, 1977-2000 (linear models expressed as y = bx + a).

Substrate Class	***Ordinary Least Squares***				***Autoregression***		
	a	***b***	***r^2***	***Dw[a]***	***a***	***b***	***r^2***
Large Fines	-490.4	0.3**	0.04	1.18**	-487.1	0.3**	0.23
Coarse Fines	-365.3	0.2**	0.03	1.12**	-361.4	0.2**	0.25
Small Fines	-3.3	0.0	0.00	1.21**	-0.2	0.0	0.18
GMPD[b]	-439.3	0.2**	0.01	0.91**	-423.4	0.2	0.33

[a]DW - First order Durbin-Watson statistic.
[b]GMPD - Geometric mean particle diameter.
†Moderately significant (P≤0.10)
*Significant (P≤0.05).
**Highly significant (P≤0.01).

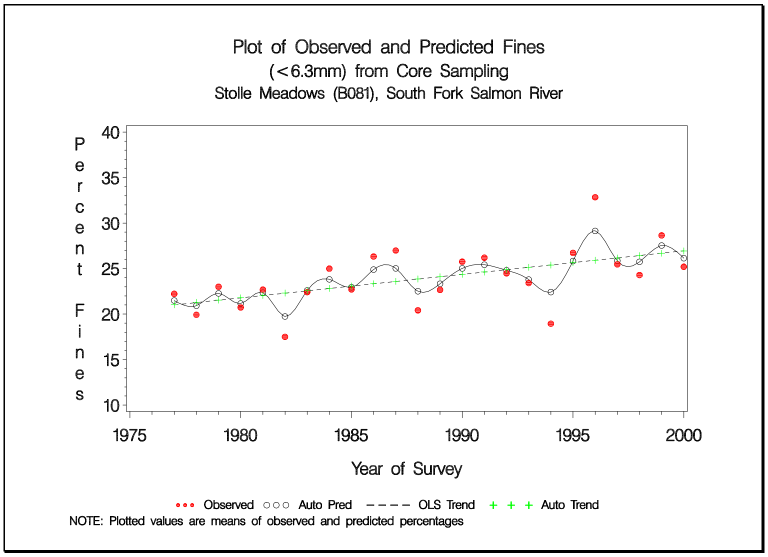

Figure 13.—Time trends in large fine sediments in Stolle Meadows spawning area, upper SFSR, 1977-2000.

should be noted that some of the sampling locations were slightly different in 1998 than in 1997, but this is a normal aspect of the BNF sampling protocol: locations are moved occasionally to ensure that they are taken from areas that are suitable for spawning (Dale Olson, formerly Fisheries Biologist, Cascade RD, personal communication).

Dollar Creek.— The Dollar Creek spawning area is downstream from the Stolle Meadows area and the Cascade-Warm Lake Road bridge upstream of the mouth of Dollar Creek, and the stream has widened considerably by this point. Nelson et. al. (1996) reported declining trends in all size fractions of fine sediments at this site, and Nelson et al. (1998) reported that coarse and small fines continued to decline despite a moderation in the trend for large fines. These patterns were obscured even more in 1998, with a large apparent increase in all categories of fine sediments and a drop in geometric mean particle diameter (Table 3). The trend in large fines now appears to be upward (Table 3), with no statistically detectable trends in the smaller fractions. In 1999 and 2000, however, all classes of fine sediments declined to well below 1998 levels, but an upward trend in geometric mean particle diameter continued to be evident.

Poverty Flat.—The Poverty Flat spawning area, located about 18mi (30km) downstream from the Cascade-Warm Lake Road bridge, is typically regarded as the most important of the SFSR spawning

Table 3.—Regression parameter estimates for fine sediments and geometric mean particle diameter, Dollar spawning area, 1977-2000 (linear models expressed as y = bx + a).

Substrate Class	***Ordinary Least Squares***				***Autoregression***		
	a	***b***	***r^2***	***Dw[a]***	***a***	***b***	***r^2***
Large Fines	-121.7	0.1*	0.00	1.19**	-109.8	0.1	0.20
Coarse Fines	35.5	-0.0	0.00	1.17**	47.7	-0.0	0.21
Small Fines	176.8	-0.1**	0.06	0.80**	185.2	-0.1**	0.44
GMPD[b]	-455.7	0.2**	0.02	0.98**	-468.1	0.2*	0.35

[a]DW - First order Durbin-Watson statistic.
[b]GMPD - Geometric mean particle diameter.
†Moderately significant (P≤0.10)
*Significant (P≤0.05).
**Highly significant (P≤0.01).

areas. In addition, it has typically been one of the most sedimented of the monitored spawning areas and one of the slowest to recover from the sediment inundation that occurred in 1964-65. Nelson et al. (1997) reported that, despite some annual variation, the level of large fines in 1996 was nearly identical to that from 1977 and was higher than the 20-year average for the site. In 1997, all categories of fines were even higher than in 1996, due primarily to a large increase in the proportion of the smallest fraction (Table 4). In 1998, however, fines dropped across the board to their lowest level during the monitoring period. Large and coarse fines appear to be relatively stable over time (Table 4), but there is a fairly strong declining trend in small fines (Figure 14) and a correspondingly strong and highly statistically significant upward trend in geometric mean particle diameter that has remained detectable for several years.

Table 4.—Regression parameter estimates for fine sediments and geometric mean particle diameter, Poverty spawning area, 1977-2000 (linear models expressed as y = bx + a).

Substrate Class	***Ordinary Least Squares***				***Autoregression***		
	a	***b***	***r^2***	***Dw[a]***	***a***	***b***	***r^2***
Large Fines	5.2	0.0	0.00	1.19**	-8.3	0.0	0.18
Coarse Fines	135.2	-0.1	0.00	1.18**	120.9	-0.0	0.18
Small Fines	423.2	-0.2**	0.13	0.87**	418.0	-0.2**	0.45
GMPD[b]	-713.0	0.4**	0.06	0.92**	-680.6	0.4**	0.37

[a]DW - First order Durbin-Watson statistic.
[b]GMPD - Geometric mean particle diameter.
[†]Moderately significant (P≤0.10)
*Significant (P≤0.05).
**Highly significant (P≤0.01).

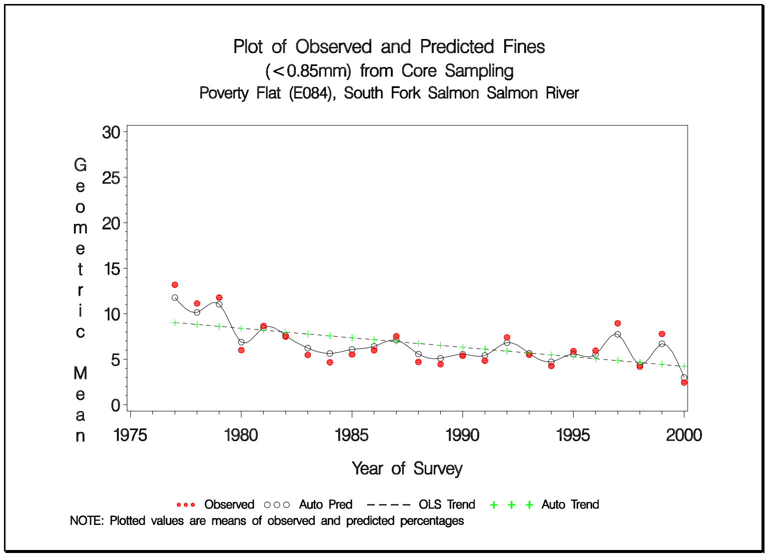

Figure 14.—Time trends in small fine sediments in the Poverty Flat spawning area, upper SFSR, 1977-2000.

Oxbow.—The next monitoring site downstream is in a part of the SFSR called the 'Oxbow' because of its dramatic horseshoe shape. A partial breach of the landform that caused the oxbow shape was created in the early 1900s, and during the record high flows in 1974, the breach was downcut sufficiently to capture most of the flow of the river. Prior to substantial flow diversion, this was a very important salmon and steelhead spawning area, ranking near Poverty Flat and Stolle Meadows in importance (Corley and Burmeister 1980).

Table 5.—Regression parameter estimates for fine sediments and geometric mean particle diameter, Oxbow spawning area, 1977-2000 (linear models expressed as y = bx + a).

Substrate Class	***Ordinary Least Squares***				***Autoregression***		
	a	***b***	***r^2***	***Dw[a]***	***a***	***b***	***r^2***
Large Fines	425.1	-0.2**	0.03	1.28**	433.9	-0.2**	0.20
Coarse Fines	661.9	-0.3**	0.09	1.20**	674.7	-0.3**	0.28
Small Fines	305.2	-0.2**	0.12	1.02**	307.2	-0.2**	0.37
GMPD[b]	-738.4	0.4**	0.08	0.97**	-763.5	0.4**	0.35

[a]DW - First order Durbin-Watson statistic.
[b]GMPD - Geometric mean particle diameter.
[†]Moderately significant (P≤0.10)
*Significant (P≤0.05).
**Highly significant (P≤0.01).

This area is active hydrologically and geomorphically because of the breach, and data interpretation is difficult. Previous reports (Newberry and Corley 1984; Nelson et al. 1996, 1997, 1998; USFS 1993) have reported declining trends for fine sediments in the Oxbow spawning area, and, although there has been considerable fluctuation from year to year in measured intragravel conditions, time series analyses extended to include data collected in 1999 and 2000 continued to support the conclusion that the streambed is in this area is coarsening; however, geometric mean particle diameter has been somewhat lower since about 1995 than it was in the 1980s (Figure 15). All classes of fines exhibited highly significant declining trends with OLS regression modeling, and geometric mean particle diameter showed a statistically significant upward trend (Table 5, previous page). Autoregressive modeling, however, only produced statistically detectable trends for large and small fines. It appeared that the sharpest declines were in the large fines category with a modeled slope (b) of -0.2; however, annual fluctuation appears to have increased since about 1990 (Figure 15), and levels in 1997 were very high.

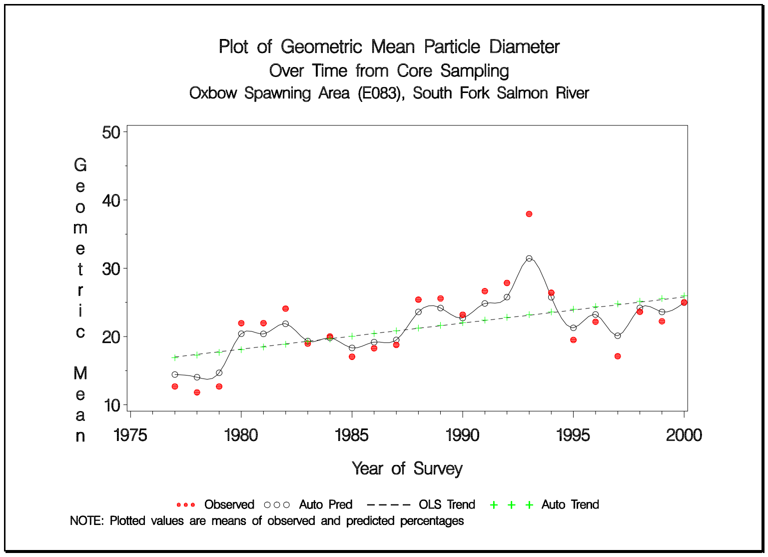

Figure 15.—Time trends in geometric mean particle diameter in the Oxbow spawning area, upper SFSR, 1977-2000.

***Glory Hole.*—**Nelson et al. (1996) documented strongly decreasing trends in all classes of fine sediments and geometric mean particle diameter at the Glory Hole site near Krassel Ranger Station, though the 1995 values appeared to reflect deterioration from 1994 to 1995. More recent data (Nelson et al. 1998), however, suggested that this area was entering a period of increasing fine material in the streambed. The 1998 sampling data (Table 1) strengthened this suggestion, and fairly strong apparent upward trends for large and coarse fines were indicated in the current analysis (Table 6).

The Glory Hole site reflects an unusual situation. Whereas all classes of fine sediments appeared to be increasing after OLS modeling, both large and small fines seemed to be behaving oppositely with autoregressive modeling. The presence of pronounced serial autocorrelation, as evidenced by the highly statistically significant Durbin-Watson statistics, indicate that the autoregressive models are superior to the OLS models. Inspection of the data scatter (Figure 16, next page) supports the suggestion we made previously (Nelson et al. 1999) that there was a sudden increase in fines in 1996, followed generally by a stable to possibly declining trend

Interestingly, values of all sediment

Table 6.—Regression parameter estimates for fine sediments and geometric mean particle diameter, Glory Hole spawning area, 1977-2000 (linear models expressed as y = bx + a).

Substrate Class	***Ordinary Least Squares***				***Autoregression***		
	a	***b***	***r^2***	***Dw[a]***	***a***	***b***	***r^2***
Large Fines	-322.4	0.2**	0.02	0.99**	-286.6	-0.2†	0.32
Coarse Fines	-234.4	0.1**	0.01	0.96**	-198.7	0.1	0.33
Small Fines	164.1	-0.1**	0.04	0.81**	165.2	-0.1*	0.45
GMPD[b]	-214.6	0.1*	0.01	0.83**	-287.0	0.2	0.39

[a]DW - First order Durbin-Watson statistic.
[b]GMPD - Geometric mean particle diameter.
†Moderately significant (P≤0.10)
*Significant (P≤0.05).
**Highly significant (P≤0.01).

measures in 1996-1998 were similar to values in 1977-1979, which was also followed by severe flood events (see Nelson et al [1998] for a discussion of the flood periods). Note the similarity in the patterns of the data points at those times in relation to the intervening period, but that the streambed now appears to be coarser than it was following the 1974 flooding.

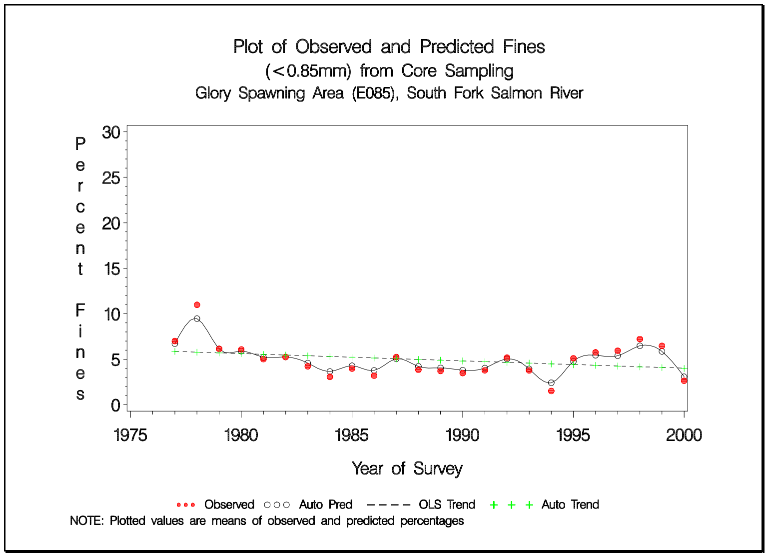

Figure 16.—Time trends in small fines in the Glory Hole spawning area, upper SFSR, 1977-2000.

Johnson Creek

Ice Hole.—The Ice Hole spawning area is on Johnson Creek near its confluence with the EFSFSR, a major tributary of the SFSR. This area has consistently been shown previously to have increasing levels of fine sediments (Newberry and Corley 1984; Nelson et al. 1996, 1997, 1998; USFS 1993), suggesting that new activities in the heavily managed Johnson Creek watershed should be approached cautiously. In 1996, the levels of large fine sediments appeared to have fallen from the long-term maximum recorded in1995 (Table 1), and they continued to decrease through 1997 and into 2000. These recent declines appear to be moderating the upward trend in large and coarse fine sediments (Table 7), but the smallest particles have proportionally increased somewhat; although they continue to show a declining trend, the slope has become very gradual and the trend in geometric mean particle

Table 7.—Regression parameter estimates for fine sediments and geometric mean particle diameter, Ice Hole spawning area, 1977-2000 (linear models expressed as y = bx + a).

Substrate Class	***Ordinary Least Squares***				***Autoregression***		
	a	***b***	***r^2***	***Dw[a]***	***a***	***b***	***r^2***
Large Fines	-150.5	0.1**	0.01	1.01**	-129.3	0.1	0.28
Coarse Fines	-39.2	0.0	0.00	1.01**	-20.0	0.0	0.28
Small Fines	89.5	-0.0**[c]	0.01	1.57**	90.9	-0.0**[c]	0.07
GMPD[b]	-830.8	0.4**	0.07	0.82**	-833.7	0.5**	0.42

[a]DW - First order Durbin-Watson statistic.
[b]GMPD - Geometric mean particle diameter.
[c]These slopes rounds to –0.0, but are actually not zero.
†Moderately significant (P≤0.10)
*Significant (P≤0.05).
**Highly significant (P≤0.01).

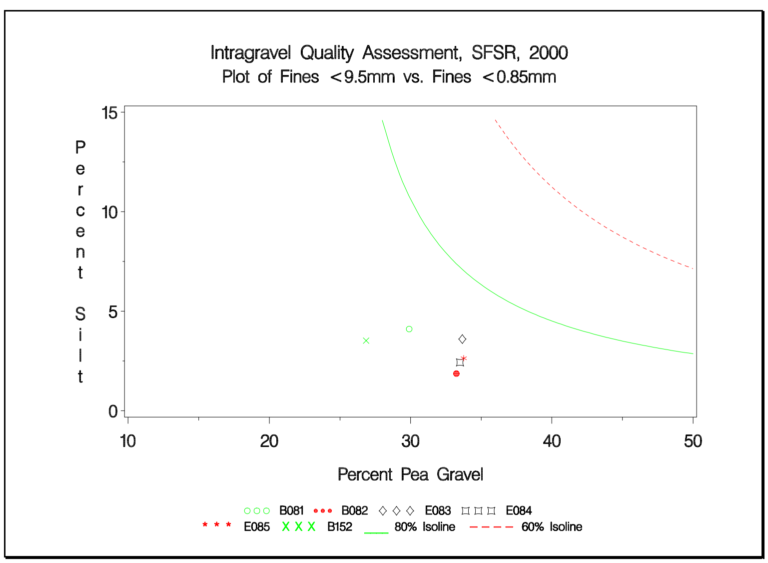

Figure 17.—Intragravel quality at the upper SFSR spawning areas, 2000.

diameter channel seems to indicate that the rate of streambed coarsening has apparently increased slightly since 1998.

Intragravel Quality

The addition of a 9.5mm screen to the BNF sampling protocol in 1997 enabled estimation of intragravel quality according to the technique proposed by Tappel and Bjornn (1983). This provides a useful way of visualizing substrate quality for spawning by anadromous fish (Figure 17, previous page), particularly chinook salmon, because data points that fall to the left of the two curved lines have approximately 80% and 60% survival probability (under controlled laboratory conditions), respectively. (The technique can also be used for steelhead, but the survival isolines are slightly different, and we have chosen to investigate only the one index). Comparison of the distribution in Figure 17 with that displayed in Nelson et al. (1999) indicates that the quality was similar for the Stolle, Poverty Flat, and Ice Hole spawning areas and better at the others in 2000. Overall, spawning gravel quality appeared to be quite good in 2000.

SECESH RIVER

Time Series Analysis

The Secesh River and Lake Creek monitoring sites continue to be among the sites with the lowest proportions of fine sediments in the streambed. Except for the relatively highly sedimented Threemile Creek site, these spawning areas are generally similar to the Chamberlain Creek site in the FCRONRW. Unlike the spawning areas in the SFSR itself, however, most of the Lake Creek/Secesh River sites showed an apparent slight increase in fine sediments in 1998 (Table 8, previous page).

***Corduroy Junction.*—**The Corduroy Junction site is the farthest upstream and typically one containing some of the lowest proportions of fine sediments. Nelson et al. (1996, 1997) reported that fine sediments were likely increasing in this area, and core sampling since 1997 (Table 9) affirmed that the overall trends are toward increasing large and coarse fine sediments, with no detectable trend in the smaller particles. Ordinary least squares regression appeared to detect a weak upward trend in small fines after sampling in 1998 (Nelson et al. 1999), but that trend is now undetectable with

Table 8.--Mean annual levels[a] of subsurface fines (in percent) and geometric mean particle diameters from core sampling in monitoring sites in the Secesh River watershed above the confluence with the Secesh River, 1981-1998.

	Corduroy Junction (E034)				Burgdorf (E048)				Threemile (E033)			
Year	LF	CF	SF	GM	LF	CF	SF	GM	LF	CF	SF	GM
1981	16.3	9.4	5.4	48.0	19.4	12.8	4.5	39.5	25.8	13.8	9.4	22.9
1982	14.1	9.2	2.9	47.2	20.4	13.4	4.9	38.3	24.7	13.1	9.0	23.0
1983	16.8	11.0	3.9	47.7	20.8	13.4	5.4	41.1	28.9	17.1	9.1	19.8
1984	19.5	12.9	4.3	37.6	19.2	12.3	4.4	38.0	28.8	15.7	9.7	17.7
1985	22.2	14.4	5.7	32.8	22.0	13.9	5.6	33.3	28.0	15.0	10.0	19.7
1986	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
1987	22.3	14.9	5.2	37.7	21.6	14.2	4.7	39.1	29.2	16.7	9.3	19.4
1988	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
1989[b]	33.1	21.9	8.5	19.4	29.0	22.8	3.4	23.0	31.7	19.4	9.1	18.0
1990	23.7	16.1	5.1	28.6	19.6	12.7	4.3	39.4	27.2	14.8	9.6	18.0
1991	28.2	19.6	6.2	25.0	20.4	13.5	4.5	40.1	30.8	17.1	10.8	15.8
1992	28.5	18.1	7.4	24.4	19.8	13.6	4.4	41.5	34.9	21.6	10.1	13.8
1993	26.8	18.5	6.5	26.8	21.5	15.7	3.6	38.3	32.6	20.0	10.2	15.8
1994	NA	NA	NA	NA	21.0	14.4	3.7	37.9	57.5	43.9	11.1	7.3
1995	17.7	12.6	3.2	43.2	14.2	9.3	3.0	55.3	23.2	12.4	8.6	30.7
1996	21.9	13.9	5.6	34.3	16.8	10.3	3.8	40.7	30.0	13.6	12.8	18.9
1997	23.9	16.8	4.8	30.2	18.5	12.3	3.8	36.1	35.9	19.1	13.1	16.1
1998	20.9	14.0	4.7	35.7	16.9	11.2	3.3	54.1	31.4	17.3	10.9	18.2
1999	19.4	13.8	3.6	39.6	18.5	12.7	3.8	47.4	28.8	17.7	7.8	20.8
2000	23.1	16.1	5.0	35.0	19.6	13.0	4.2	40.1	30.4	19.8	7.9	18.9
Total	**22.3**	**14.9**	**5.2**	**34.9**	**20.0**	**13.4**	**4.2**	**40.2**	**31.1**	**18.2**	**9.9**	**18.6**

	Secesh Meadows (E096)				Chinook CG (E046)			
Year	LF	CF	SF	GM	LF	CF	SF	GM
1981	14.2	8.6	4.1	48.9	15.5	10.0	3.7	40.3
1982	17.9	11.8	4.4	38.2	15.1	9.8	3.6	46.4
1983	18.9	12.6	4.4	40.7	18.4	12.6	4.1	40.9
1984	18.6	12.6	4.0	36.4	19.8	13.7	4.1	36.8
1985	21.2	14.3	4.8	36.5	19.7	13.5	4.1	37.7
1986	20.6	13.8	4.9	38.6	NA	NA	NA	NA
1987	21.2	14.4	4.9	40.4	21.2	15.2	3.9	38.5
1988	NA	NA	NA	NA	NA	NA	NA	NA
1989	27.2	19.3	5.6	26.8	31.1	21.5	6.9	21.6
1990	22.7	15.7	4.9	33.7	24.7	19.1	3.6	29.6
1991	23.0	16.4	4.8	32.5	20.8	14.1	4.4	36.3
1992	25.2	17.0	4.6	29.3	19.4	12.9	4.4	44.5
1993	24.0	17.1	4.6	30.5	21.0	15.0	3.5	35.9
1994	24.2	17.6	3.9	32.8	23.2	16.2	4.3	34.2
1995	16.8	11.4	3.4	43.7	18.6	13.3	3.6	50.6
1996	28.0	19.5	6.4	25.7	23.1	17.7	3.2	37.2
1997	15.5	11.1	2.7	47.2	20.5	14.2	3.8	40.6
1998	19.3	13.0	4.5	43.3	20.6	13.9	4.4	44.0
1999	NA	NA	NA	NA	19.2	13.7	3.7	45.8
2000	18.3	13.1	3.9	42.5	19.2	13.3	4.1	43.4
Total	**20.9**	**14.4**	**4.5**	**37.1**	**20.6**	**14.4**	**4.1**	**39.1**

[a] LF = large fines; CF = coarse fines; SF = small fines; GM = geometric mean particle diameter.
[b] The database was discovered to contain duplicate records in 1989 for site E048; these were removed and the resulting means were slightly different than previously reported.

Table 9.—Regression parameter estimates for fine sediments and geometric mean particle diameter, Corduroy Junction spawning area, 1977-2000 (linear models expressed as y = bx + a).

Substrate Class	***Ordinary Least Squares***				***Autoregression***		
	a	***b***	***r^2***	***Dw[a]***	***a***	***b***	***r^2***
Large Fines	-471.4	0.2**	0.02	1.17**	-519.6	0.3*	0.24
Coarse Fines	-441.7	0.2**	0.03	1.28**	-478.7	0.2**	0.20
Small Fines	-4.6	0.0	0.00	1.32**	-2.8	0.0	0.15
GMPD[b]	1016.0	-0.5*	0.02	1.03**	1273.0	-0.6*	0.32

[a]DW - First order Durbin-Watson statistic.
[b]GMPD - Geometric mean particle diameter.
†Moderately significant (P≤0.10)
*Significant (P≤0.05).
**Highly significant (P≤0.01).

either modeling approach. On the other hand, the trends in large and coarse fines detected by the autoregressive approach had relatively steep slopes and were highly significant (P≤0.01) in the 1999 analysis (Nelson et al. 1999); however, the slope for large fines was only significant at the 5% level in the current analysis. In a corresponding fashion, geometric mean particle diameter was seen to be decreasing rather sharply (Figure 18). However, previous reports also suggested that a change in direction of the observed trends may have occurred about 1990, which still seems reasonable from the time trend graphs. This inference is discussed more fully later in the report.

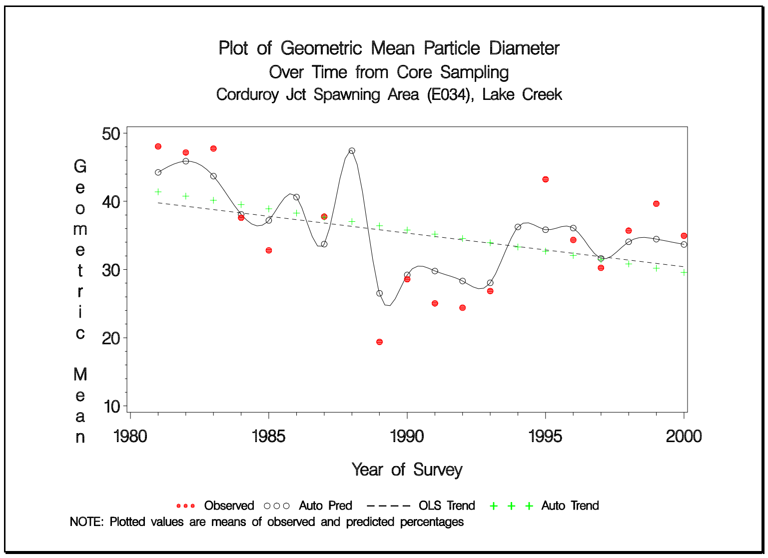

Figure 18.—Time trends in geometric mean particle diameter in the Corduroy Junction spawning area, Lake Creek, 1977-2000.

Threemile Creek.—The Threemile Creek spawning area is immediately upstream from the mouth of Threemile Creek, a recognized source of ongoing sediment input, though efforts have been underway to control the problem. It has always been difficult to accurately assess trends at this location, and prior to 1998 it had seemed as if levels of fines were fluctuating with no trend in streambed coarseness (Nelson et al. 1997, 1999); however, some of this inability to clearly identify a coarsening trend was attributed to a rather large apparent geometric mean particle diameter in 1994[5]. In this analysis, we have added another three years of data and we have eliminated the incomplete 1994 sample; now we get what appears to be a much clearer picture (Table 10). At this time, only large and coarse fines exhibited statistically significant upward trends, and we were unable to detect a downward trend in geometric mean particle diameter.

Table 10.—Regression parameter estimates for fine sediments and geometric mean particle diameter, Threemile Creek spawning area, 1977-2000 (linear models expressed as y = bx + a).

Substrate Class	***Ordinary Least Squares***				***Autoregression***		
	a	***b***	***r^2***	***Dw[a]***	***a***	***b***	***r^2***
Large Fines	-420.7	0.2**	0.02	1.07**	-399.4	0.2†	0.28
Coarse Fines	-316.5	0.1**	0.02	1.22**	-374.0	0.2*	0.25
Small Fines	-72.2	0.0	0.00	1.27**	-30.4	0.0	0.16
GMPD[b]	171.5	-0.1	0.00	0.95**	359.3	-0.2	0.32

[a]DW - First order Durbin-Watson statistic.
[b]GMPD - Geometric mean particle diameter.
†Moderately significant (P≤0.10)
*Significant (P≤0.05).
**Highly significant (P≤0.01).

[5] Incorrectly identified as 1995 in Nelson et al. (1999).

An interesting aspect of the trends in sediment conditions in the Threemile Creek spawning area is that the suggestion of a change early in the 1990s does not exist. In the case of large fines, for example, there has been some fluctuation from year to year, which seems to have become more pronounced in recent years, but the trend has been rather steadily upward (Figure 20). On the ground, sediment sources in the historically mined area of the large placer on the terraces above Lake Creek are clearly visible (Figure 21). There is a significant gold placer that extends from approximately the mouth of Threemile Creek to approximately Corduroy Junction that has been mined hydraulically and with pit excavation (Lorain and Metzger 1938).

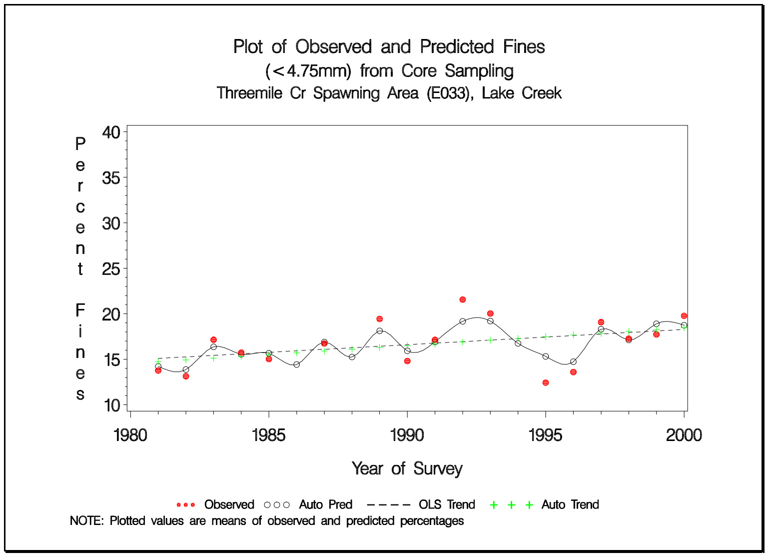

Figure 19.—Time trends in coarse fines in the Threemile Creek spawning area, Lake Creek, 1981-2000.

Figure 20.—Partially stabilized mined area in the Threemile Placer area near Burgdorf, 1999.

***Burgdorf.*—**The Burgdorf spawning area is near Burgdorf Hot Springs resort, downstream from the confluence of Threemile Creek. Despite its location downstream from the heavily sedimented Threemile Creek spawning area, the streambed in the Burgdorf spawning area has always been among the cleanest of the sampled sites in the Secesh River watershed.

Analysis with the addition of 1999 and 2000 core sampling data supports previous contentions (Nelson et al. 1997, 1999) that streambed fines are remaining essentially unchanged over time despite annual fluctuations. The trends apparently detected by ordinary least squares regression would seem to be stronger with the addition of more recent data, but the autoregressive method continued to detect a trend only for the small fines (Table 11). This suggests that the streambed may be coarsening slightly, but it is not supported by a statistically detectable upward trend in geometric mean particle diameter at this time.

***Secesh Meadows.*—**The Secesh Meadows spawning area is in the Secesh River itself, in an area of private property that has been subdivided for housing. Feelings about property rights are strong in this small community, and access to the sampling areas has become increasingly difficult. As a result, there have been several seasons when only about half the specified number of samples has been collected, which has become the usual situation; however, in 1999, no data were collected here.

Table 11.—Regression parameter estimates for fine sediments and geometric mean particle diameter, Burgdorf spawning area, 1977-2000 (linear models expressed as y = bx + a).

Substrate Class	***Ordinary Least Squares***				***Autoregression***		
	a	***b***	***r^2***	***Dw[a]***	***a***	***b***	***r^2***
Large Fines	390.0	-0.2**	0.02	1.08**	309.8	-0.1	0.31
Coarse Fines	227.1	-0.1**	0.01	1.00**	136.2	-0.1	0.36
Small Fines	162.9	-0.1**	0.05	1.27**	159.1	-0.1**	0.21
GMPD[b]	-897.9	0.5**	0.02	1.07**	-611.5	0.3	0.29

[a]DW - First order Durbin-Watson statistic.
[b]GMPD - Geometric mean particle diameter.
†Moderately significant (P≤0.10)
*Significant (P≤0.05).
**Highly significant (P≤0.01).

From the data that we have collected, however, the streambed would seem to be in relatively good condition with respect to the needs of spawning anadromous fish.

Despite the fact that fine sediments are probably not yet at dangerously high levels, it is pretty clear that they are on the increase. Increasing trends in both large (Figure 21) and coarse fines were reported in previous reports (Nelson et al. 1996, 1997, 1999), and the addition of 1999 and 2000 sampling data supports these conclusions (Table 12). There may be one bright spot, however, in that the slopes of the trend lines now appear to be somewhat less than they were modeled to be in the previous analyses. This apparent reduction in slope is likely due to the fact that the levels of fines in the 1996 sample was unusually large, whereas the level of fines in the 1997 through 2000 samples were much less.

Table 12.—Regression parameter estimates for fine sediments and geometric mean particle diameter, Secesh Meadows spawning area, 1977-2000 (linear models expressed as y = bx + a).

Substrate Class	***Ordinary Least Squares***				***Autoregression***		
	a	***b***	***r^2***	***Dw[a]***	***a***	***b***	***r^2***
Large Fines	-360.5	0.2**	0.02	1.22**	-429.7	0.2*	0.22
Coarse Fines	-382.1	0.2**	0.04	1.23**	-430.9	0.2**	0.23
Small Fines	57.8	-0.0†	0.00	1.45**	51.1	-0.0	0.09
GMPD[b]	422.7	-0.2†	0.00	0.94**	953.1	-0.5†	0.33

[a]DW - First order Durbin-Watson statistic.
[b]GMPD - Geometric mean particle diameter.
†Moderately significant (P≤0.10).
*Significant (P≤0.05).
**Highly significant (P≤0.01).

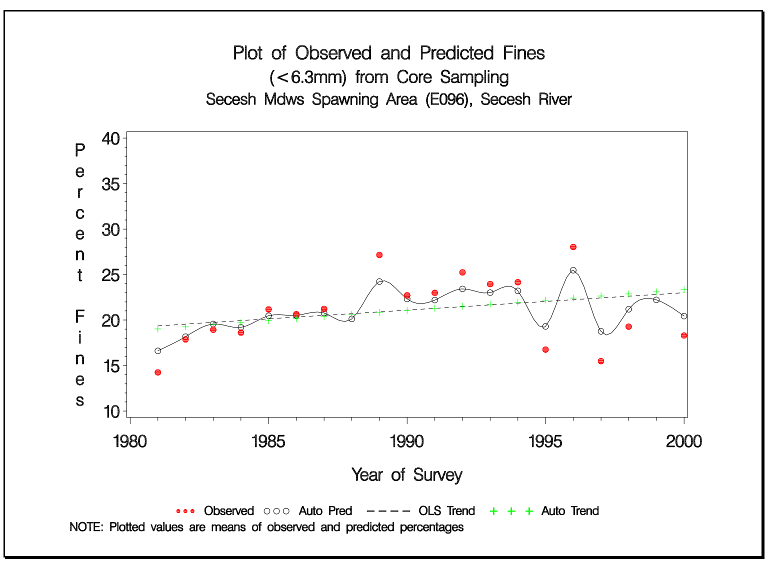

Figure 21.—Time trends in large fines in the Secesh Meadows spawning area, 1981-2000.

Chinook Campground.— The Chinook Campground spawning area is the farthest downstream of the monitored spawning areas. It has typically had relatively low levels of fine sediments in the streambed, but the increasing trends that were reported in previous reports (Nelson et al. 1996, 1997, 1999) are still in evidence with this analysis. These upward trends are in the large and coarse fines fractions (Table 13, next page), and they may be moderating, because their slopes appear to have flattened somewhat and their statistical significance was less in this analysis than in previous analyses.

Sediment Trends and the Forest Plan

In past reports (Nelson et al. 1996, 1997), and occasionally in this report, we have mentioned the possibility of a change in the trends in the condition of streambed sediments about 1989 or 1990. The current Forest Plan was released in 1989, and contains direction to implement a variety of improvements in the Secesh River watershed. Clearly, if sediment trends have changed since 1989, there would be important implications for how we viewed the success of the Forest Plan.

We first formally modeled this suspected relationship in the previous report (Nelson et al. 1999). Current results of these analyses including 1999 and 2000 data are presented in Table 14, and it is reasonable to conclude that there are different trends on either side of 1989. In the former period, there were strong, statistically significant (P≤0.05) positive trends in large and coarse fine sediments, and an equally significant downward trend in geometric mean particle diameter. After 1989, however, we modeled statistically highly significant (P≤0.01) downward trends in these same classes of fine sediments and an upward trend in geometric mean particle diameter; again, there was no detectable trend in small fines, though the non-significant slope did change sign. A visual representation of these trends, with geometric mean particle diameter illustrated, is presented in Figure 22.

Table 13.—Regression parameter estimates for fine sediments and geometric mean particle diameter, Chinook Campground spawning area, 1977-2000 (linear models expressed as y = bx + a).

Substrate Class	*Ordinary Least Squares*				*Autoregression*		
	a	*b*	*r^2*	*Dw*[a]	*a*	*b*	*r^2*
Large Fines	-262.0	0.1**	0.01	0.85**	-428.6	0.2†	0.41
Coarse Fines	-254.8	0.1**	0.02	0.80**	-371.2	0.2†	0.45
Small Fines	22.5	-0.0	0.00	1.17**	6.7	-0.0	0.22
GMPD[b]	-386.4	0.2†	0.00	0.93**	177.5	-0.1	0.38

[a]DW - First order Durbin-Watson statistic.
[b]GMPD - Geometric mean particle diameter.
†Moderately significant (P≤0.10)
*Significant (P≤0.05).
**Highly significant (P≤0.01).

Table 14.—Autoregressive parameter estimates for fine sediments and geometric mean particle diameter, all spawning areas, 1981-1989 and 1990-2000 (linear models expressed as y = bx + a).

Class	*1981-1989*			*1990-2000*		
	a	*b*	*r^2*	*a*	*b*	*r^2*
Large Fines	-2804.0	1.4**	0.37	579.3	-0.3*	0.35
Coarse Fines	-2445.0	1.2**	0.40	452.8	-0.2*	0.29
Small Fines	-126.4	0.1	0.35	89.2	-0.0	0.39
GMPD[b]	3936.0	-2.0**	0.36	-1670.0	0.9**	0.38

[a]DW - First order Durbin-Watson statistic.
[b]GMPD - Geometric mean particle diameter.
†Moderately significant (P≤0.10)
*Significant (P≤0.05).
**Highly significant (P≤0.01).

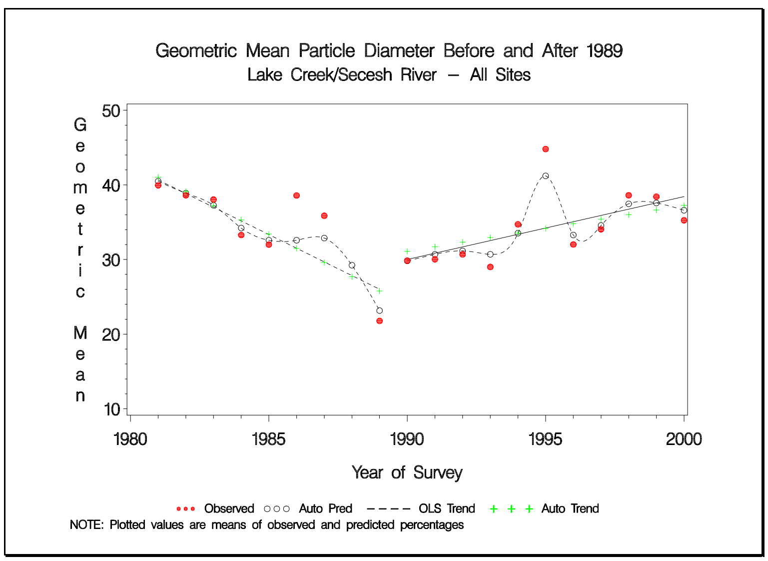

Figure 22.—Time trends in geometric mean particle diameter in the Lake Creek/Secesh River spawning areas, before and after 1989.

Intragravel Quality

Except for the Threemile Creek spawning area and other occasional exceptions, intragravel quality evaluated according to the technique proposed by Tappel and Bjornn (1983) has consistently been reported to be high (above a predicted embryo survival of 80%) for chinook salmon (Lund 1984, 1985; Nelson et al. 1996, 1997, 1999). Although the graph in Figure 23 does not separate samples by year, none of the points between the 80% and 60% survival isolines were from any 1997 through 2000 samples taken from anywhere other than the Threemile Creek spawning area, indicating that the other spawning areas contain a favorable mix of sediments for salmon spawning. Despite positive trends in most classes of fine sediments since 1981, there does not seem to be any organized shift to the right on this graph, though the apparent trend reversals may be partially responsible.

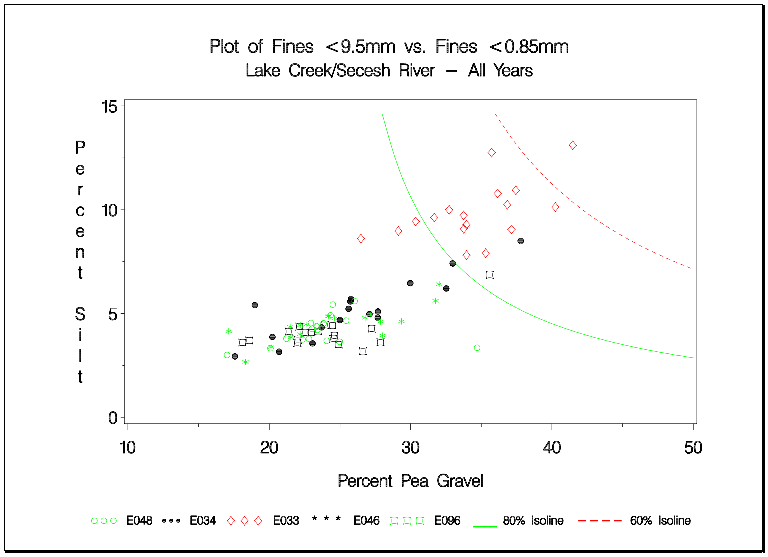

Figure 23.— Intragravel quality at the Lake Creek/Secesh River spawning areas, 1981-2000 (see *Study Areas* for site codes).

CHAMBERLAIN BASIN

Time Series Analysis

Core samples were evaluated at two spawning areas in the Chamberlain Basin, one on Chamberlain Creek and one on West Fork Chamberlain Creek, and annual means are presented in Table 15. Except for 1996, fine sediments have generally decreased in the Chamberlain Creek spawning area, but conditions have remained relatively stable in the West Fork Chamberlain Creek spawning area.

Table 15.--Mean annual levels[a] of subsurface fines (in percent) and geometric mean particle diameters from core sampling in monitoring sites in the Chamberlain Creek watershed, 1981-2000[b].

Year	Chamberlain Creek (E032)				WF Chamberlain Cr (E136)			
	LF	CF	SF	GM	LF	CF	SF	GM
1981	24.6	15.0	7.0	30.4	NA	NA	NA	NA
1982	NA	NA	NA	NA	NA	NA	NA	NA
1983	NA	NA	NA	NA	NA	NA	NA	NA
1984	NA	NA	NA	NA	NA	NA	NA	NA
1985	NA	NA	NA	NA	NA	NA	NA	NA
1986	NA	NA	NA	NA	NA	NA	NA	NA
1987	NA	NA	NA	NA	NA	NA	NA	NA
1988	NA	NA	NA	NA	NA	NA	NA	NA
1989	31.8	22.7	5.8	23.3	NA	NA	NA	NA
1990	28.6	20.8	4.7	28.4	NA	NA	NA	NA
1991	26.4	18.4	5.1	33.5	29.0	17.9	8.4	23.2
1992	28.5	19.9	5.7	28.7	31.9	21.0	8.3	19.5
1993	21.9	17.1	2.8	42.2	31.4	21.3	6.9	20.9
1994	22.4	15.5	4.4	41.3	26.0	18.1	5.4	23.3
1995	16.9	12.8	2.3	61.5	25.1	16.5	6.0	26.0
1996	23.9	18.5	3.0	39.6	34.2	24.6	6.6	18.4
1997	15.7	11.3	2.3	55.6	28.7	19.3	6.3	22.6
1998	13.9	9.6	2.6	68.8	30.6	21.9	5.4	20.4
1999	17.2	12.4	2.7	60.0	31.5	22.5	6.1	20.3
2000	19.8	15.0	3.1	52.4	33.4	23.1	7.4	18.6
Total[c]	22.4	16.1	4.0	43.5	30.2	20.6	6.7	21.3

[a] LF = large fines; CF = coarse fines; SF = small fines; GM = geometric mean particle diameter.
[b] 1989 and 1990 data for West Fork Chamberlain Creek omitted due to data irregularities (see *Quality Assurance and Quality Control*.
[c] Totals are combined averages for each site using raw data (it is not the average of the annual means).

***Chamberlain Creek.*—**The time series indicates that fine sediments were relatively high in the late-1980s and early-1990s (compared with the sample in 1981) and have subsequently

Table 16.—Regression parameter estimates for fine sediments and geometric mean particle diameter, Chamberlain Creek spawning area, 1989-2000 (linear models expressed as y = bx + a).

Substrate Class	Ordinary Least Squares				Autoregression		
	a	b	r^2	Dw[a]	a	b	r^2
Large Fines	2700.0	-1.3**	0.25	1.25**	2431.0	-1.2**	0.38
Coarse Fines	1845.0	-0.9**	0.20	1.26**	1640.0	-0.8**	0.34
Small Fines	581.7	-0.3**	0.22	1.34**	548.7	-0.3**	0.32
GMPD[b]	-6910.0	3.5**	0.20	1.29**	-6455.0	3.3**	0.31

[a]DW - First order Durbin-Watson statistic.
[b]GMPD - Geometric mean particle diameter.
†Moderately significant (P≤0.10)
*Significant (P≤0.05).
**Highly significant (P≤0.01).

returned to levels similar to our earliest sample. We do not know why sediment conditions were different during that period, which represents the actual beginning of our time series, but it is clear from the regression models (Table 16) that sediment conditions in the Chamberlain Creek spawning area have been changing for the past several years. There were strong, highly statistically significant downward trends in both large and coarse fines, a more moderate but equally significant negative trend in small fines, and a strong upward trend in geometric mean particle diameter. It is interesting to note that, while there is little anthropogenic disturbance in the Chamberlain Creek watershed above the confluence of the West Fork related to forest commodity development, the upper reaches of the watershed were within the perimeter of the 1994 Chicken Fire Complex. Shortly thereafter (1996), fine sediments were perhaps elevated slightly; however, they appear to have generally declined since 1989. Sediment response to the 2000 Flossie Fire, if any, will be interesting to observe.

West Fork Chamberlain Creek.—Previous reports included analyses using 1989 and 1991 data that have been omitted from the current analysis because we discovered obvious irregularities in the field data. For these two years, a torn sieve is thought to have resulted in underestimation of fine sediments, and trends modeled in this analysis are expected to be considerably more accurate. In fact, trends detected in this analysis (Table 17) are almost the reverse of what we reported in the previous report (Nelson et al. 1999). Increasing trends were detected for large and coarse fines, whereas we detected decreasing trends in both small fines (Figure 24) and geometric mean particle diameter.

Correction to Previous Reports.—Past sediment monitoring reports evaluated trends for the West Fork Chamberlain Creek with data beginning in 1989, but the first two years, 1989 and 1990, appeared to be inappropriate. For this report, we took a close look at the raw data sheets and discovered that there were data collection errors in these two years that resulted from a torn sieve. Data for those two years were eliminated from this analysis.

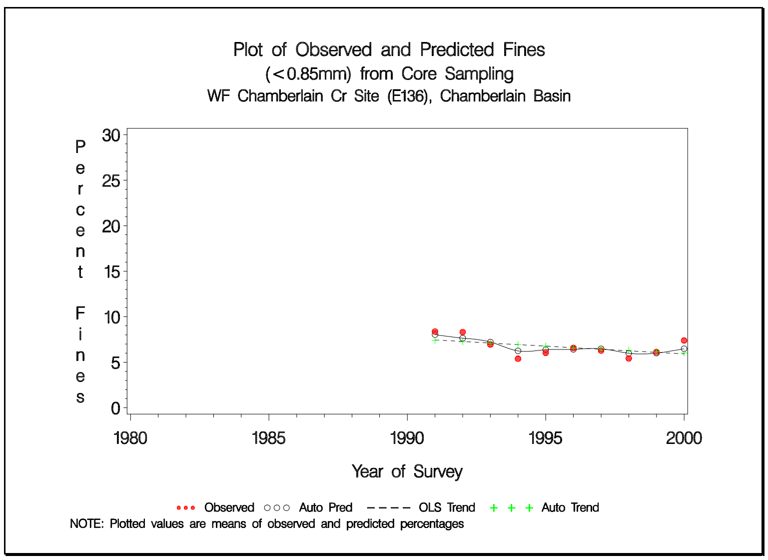

Figure 24.—Time trends in small fine sediments, West Fork Chamberlain Creek spawning area, 1991-2000.

Table 17.—Regression parameter estimates for fine sediments and geometric mean particle diameter, West Fork Chamberlain Creek spawning area, 1991-2000 (linear models expressed as y = bx + a).

Substrate Class	Ordinary Least Squares				Autoregression		
	a	b	r^2	Dw[a]	a	b	r^2
Large Fines	-568.0	0.3*	0.01	1.36**	-1075.0	0.6*	0.20
Coarse Fines	-841.8	0.4**	0.04	1.47**	-1159.0	0.6**	0.16
Small Fines	347.9	-0.2**	0.04	1.33**	314.9	-0.2*	0.20
GMPD[b]	593.8	-0.3*	0.01	1.43**	932.0	-0.5*	0.13

[a]DW - First order Durbin-Watson statistic.
[b]GMPD - Geometric mean particle diameter.
†Moderately significant (P≤0.10)
*Significant (P≤0.05).
**Highly significant (P≤0.01).

Intragravel Quality

Intragravel quality in the Chamberlain Creek spawning area was higher than previously, whereas conditions were similar to previous years in the West Fork Chamberlain Creek spawning area. Only one point in the former site has ever been below the 80% isoline (Figure 25), while most of the points from the West Fork spawning area have been below the 80% survival line.

Interbasin Comparisons

The Chamberlain Basin spawning areas were intended to serve as control sites for geologically similar watersheds regularly or formerly managed for more development. Although such activities have declined in both the SFSR and Secesh River watersheds in recent years, both do have a legacy of effects from land disturbance.

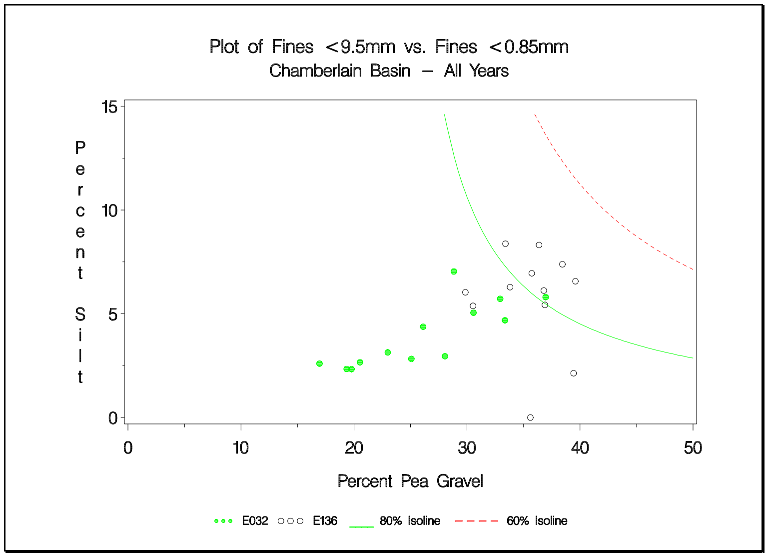

Figure 25.—Intragravel quality at the Chamberlain Basin spawning areas, 1989-2000.

We have omitted the cluster analysis for this report because of technical problems with our installation of the JMP® software, but we have retained the multiple comparison of the mean values for geometric mean particle diameter by year (Table 18). This comparison shows that there were few consistent differences among basins from 1989 through 1994, but that, beginning in 1995 and through 2000, the SFSR sites consistently had a lower average geometric mean particle diameter than the sites in the other two basins. Furthermore, since 1997, all three basins have differed significantly with the Chamberlain Basin having the largest average geometric mean particle diameter, the SFSR the lowest. This corresponds well with the estimates of time trends, with the Chamberlain Creek spawning area exhibiting a steadily increasing geometric mean particle diameter, the Lake Creek/Secesh River spawning areas also increasing somewhat since 1989, and the SFSR sites remaining relatively stable. Interestingly, however, the 2000 comparison provided the first instance of their not being any statistically significant difference in geometric mean particle diameter among the three basins.

Table 18.—Multiple comparison[a] of mean geometric mean particle diameters among basins by year.

Year	SFSR	Secesh	Chamberlain
1989	29.3 A	21.8 B	23.3 B[b]
1990	26.7 A	29.8 A	28.4 A[b]
1991	28.9 A	30.0 A	28.5 A
1992	29.7 A	30.7 A	24.1 B
1993	27.7 B	29.0 AB	31.6 B
1994	35.9 A	32.4 A	32.3 A
1995	23.1 B	44.8 A	43.7 A
1996	24.0 B	32.0 A	29.0 A
1997	23.8 C	34.1 B	39.1 A
1998	24.4 C	38.6 B	44.6 A
1999	24.2 B	38.4 A	40.2 A
2000	31.1 A	35.3 A	35.5 A

[a] Mean values with different letters are significantly different ($P \leq 0.10$).
[b] Values for Chamberlain Basin have changed from previous reports because 1989 and 1990 data for West Fork Chamberlain Creek were discarded (see above).

Photographic Record

During 1999 and 2000, we searched the Forest's historical archives for photographs that showed identifiable parts of the Upper South Fork Salmon River and tried to reproduce the photographs[6] to show current conditions at those locations. Although we located several photographs, only three were at locations we could accurately identify: Poverty Flat (ca. 1938 and 2000),

[6] Images obtained with a digital camera are considered photographs for the purposes of this report, and no differentiation between true photographs and digital images is made.

the area at the confluences of Camp and Phoebe Creeks (1955 and 2000), and just downstream of Buckhorn Creek (1937 and 2000[7]). In addition, we obtained one photograph of the river in the "Binwall" area from an early monitoring report (Corely and Burmeister 1978) and reproduced it in the spring of 2001 before the river began to rise appreciably. Of these photographs, the historic Poverty Flat photograph is unusual in that it was a hand-painted photograph and we do not know the exact date of creation; however, we know that it was from approximately 1938. These photographs are displayed as pairs (Appendix 4) and discussed below.

The first pair of images reflects the longest time period. The early photo was taken shortly after the SFSR Road was created (in fact, we have a photo from immediately prior to construction of the road prism, but it is of poor quality). The most noticeable changes over time illustrated by this pair of images is the increase in shrubby cutslope vegetation and young trees, which are the result of years of hand planting and natural seeding; notice, also, that the large pine in the foreground is leaning farther out over the river in 2000 than it was in 1937.

The second pair of images reflects almost the same time period as the previous pair. This pair of images clearly show that the river has migrated toward the east (i.e., toward the road) in this area, and trees on the eastern bank seem to be leaning farther out over the river than they were in the 1930s; streambank vegetation also appears to be much more robust in the recent image, but we have no idea why this would be so. Another interesting feature of the 1930s image is that there appears to be considerable evidence of stand replacing wildfire on the mountains surrounding the river, indicating that stand replacing fire occurred in the past.

The third pair of images reflect a shorter time interval, but more clearly shows the condition of the SFSR prior to the 1964-65 floods. It is clear from this image that the river has moved westward in this area, and that there were considerable sand deposits even in 1955. These images are from near the mouths of Phoebe and Camp Creeks, where some timber harvest had occurred prior to 1955 and some concern over logging-related sedimentation had already been reported (Heikkenen n.d.; Varner 1948).

The final pair of images show the SFSR the year after the 1964-65 event and earlier this year. It is clear the amount of sandy surface material in this reach has diminished over the past 36 years.

[7] This photograph was taken too late in the year to achieve comparable sun angles, and glare and shadows obscure important features. We hope to re-photograph this location in 2001.

Conclusions

Upper South Fork Salmon River

Sediment trends have been a major concern in the SFSR since the winter storms of 1964-65 inundated several important chinook salmon spawning and rearing areas. Monitoring of intragravel conditions with core samples has been performed every year since then, and it has generally been assumed that, following an initial decline for about 10 years after the event, subsurface fines have been relatively stable, but possibly starting to increase about 1986 (Platts et al. 1989). Our analyses agree that subsurface sediments appear to be relatively stable (Figure 26), but we have modeled trends that indicate continued coarsening of the streambed, even though this is not readily apparent from the "averaged" values in the figure. (Note that the Oxbow spawning area was omitted from this graph for consistency with Platts et al. (1989); the Oxbow area is unusual hydrologically because of mechanical alterations to the river, but it also has one of the strongest downward trends in fine particles). In general, core sampling results from 1996 through 1999 revealed higher levels of large fines than in the rest of the period after 1973, and the slopes and significance of the declining trends were correspondingly reduced after 1996 (Nelson et al. 1997, 1999). Note, however, that the situation appears to be different for small fines, which remained lower than levels reported as recently as 1979 and have been essentially stable since about 1981. There is clearly considerable annual variability in the core samples, and there is no known reason for an increase in fines after 1994; however, runoff and flooding were higher than normal every year from 1995 through 1999 (Figure 27). It is also clear that fines did increase for a short period from about 1985 to 1987; we have not modeled pre-1985 and post-1985 separately, but it might be interesting to do so. After a 20-year moratorium, limited logging began in the watershed in the 1980s and again after the Thunderbolt Fire of 1994. The general pattern of the time series appears to have changed slightly in about 1982, particularly with respect to the annual

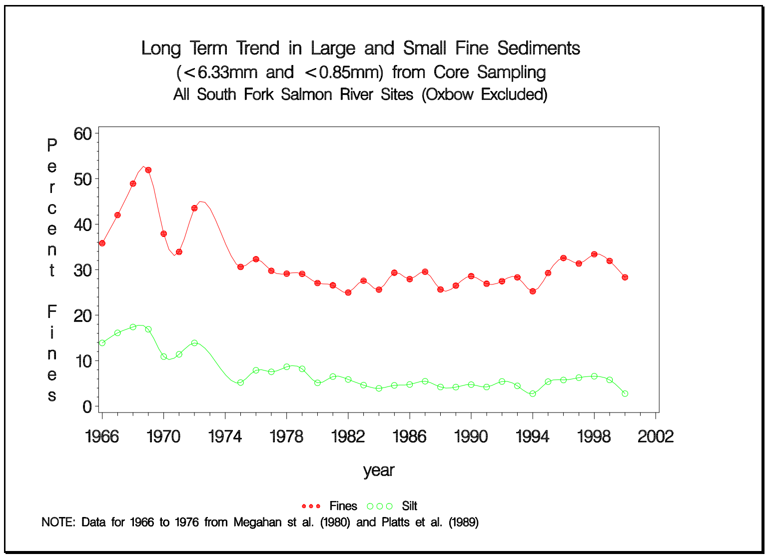

Figure 26.—Proportions of large and small fines from sediment cores in the SFSR, 1966-2000.

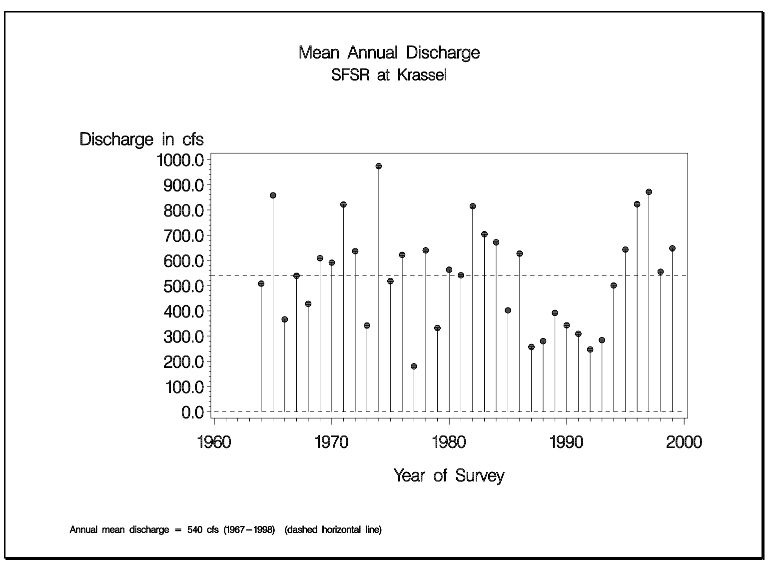

Figure 27.—Mean daily streamflow in the SFSR at Krassel, Idaho, 1964-1999.

variation in all fines smaller than 6.3mm in particle diameter.

Although the trend in Figure 26 appears to indicate increasing large fines, we question whether there is ongoing degradation of the SFSR streambed. The Dollar Creek and Glory Hole areas appear to be sites of localized deposition that attenuates slowly. Several consecutive recent years have been unusual hydrologically in that high flows and even flooding has been common. Although the highest mean annual discharge on record at the Krassel Gage occurred in 1974 (974cfs [27.6cms]), there have been several "near misses" in recent years, as well as several significant mid-winter peaks. In 1997, the mean annual discharge was just 11% lower at 871cfs (24.7cms), and actually set record mean monthly maximum flows of 860cfs (24.4cms) and 3,208cfs (90.9cms) for January and May, respectively. The high mid-winter flows are often associated with rain-on-snow events and widespread hillslope failures when there is a low-elevation snowpack. This can be aggravated by imprudent land-use, as occurred in the 1964-65 "Christmas Floods," but may also occur in relatively undisturbed areas (Figure 28). The aerial photograph in Figure 28 shows two small watersheds tributary to the Lower SFSR that had not been developed, though they were inside the perimeter of the 1994 Chicken Fire complex, which may account for the extensive treeless areas. The red markings (visible on color copies of this document) indicate individual failures that occurred early in 1997 from rain-on-snow events (the photograph was actually taken in 1998, but the failures are believed to have occurred primarily in 1997).

Water year 1998 was just slightly above average with respect to peak runoff, and was not as high as either 1996 or 1997, but 1999 was again above average. This situation now seems to have changed somewhat. Although USGS flow data for water year 2000 are not yet available, snow water content in 2000 was less than in 1998 (Figure 29), and should have generated peak flows somewhat below average. In addition, water year 2001 will have peak flows much lower than average because of a very light snowpack (Figure 29).

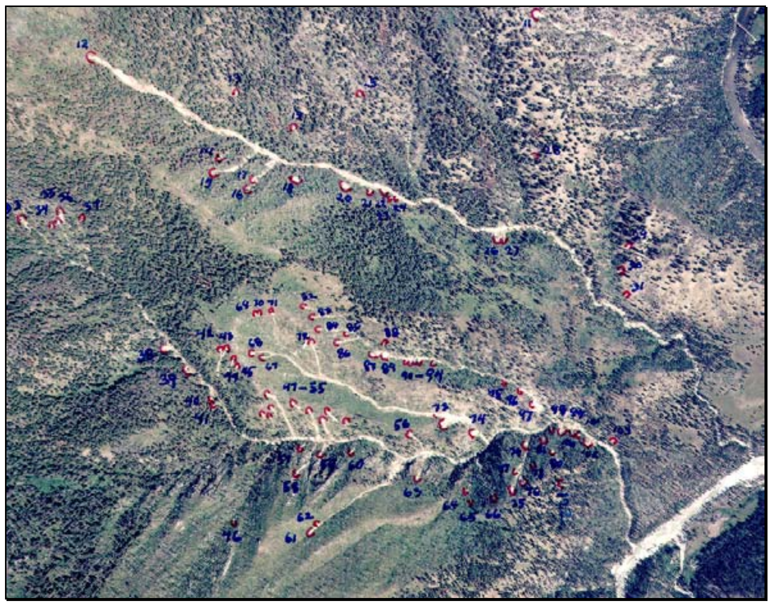

Figure 28.—Hillslope failures on the lower SFSR near Contux Creek, 1997 (photograph taken in 1998, slides are believed to have resulted from 1997 rain-on-snow events, Mike Dixon, Civil Engineer, Payette National Forest).

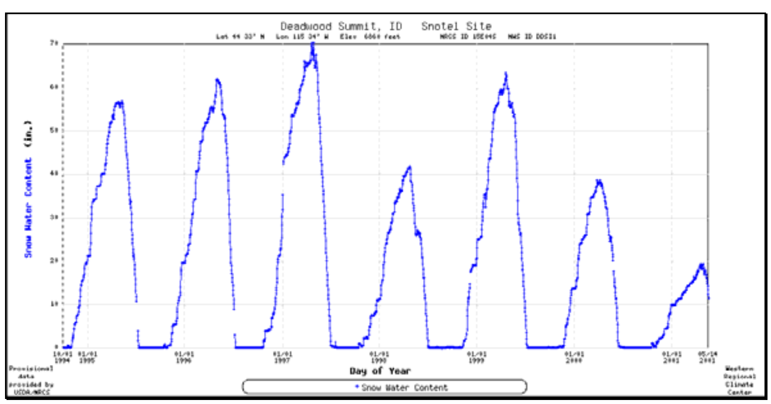

Figure 29.—Daily snow water equivalent at Deadwood Summit, Idaho, water years 1995 to present (from USDA NRCS SNOTEL monitoring).

The significance of the above discussion is that the SFSR watershed is in substantially different condition now than it was immediately before the 1964-65 “Christmas Floods.” Since then, extensive effort has been directed at stabilizing the watershed through road improvements and closures and by limiting new timber harvest. In addition, areas previously harvested and other rehabilitated areas have had 30 or more years to recover. Recently, there have been several significant natural events, including two large fires (the 1989 Warm Lake complex at about 30,000ac [12,141ha] and the 1994 Thunderbolt fire at about 19,000ac [7,689ha]), exceptionally high snowpacks and spring runoff in 1996 and 1997, higher than normal snowpacks in 1998 and 1999, and widespread hillslope failures in early 1997 following rain-on-snow events that were probably very similar to the “Christmas Floods” of 1964-65 (Nelson et al. 1998). Despite these events, streambed conditions have fluctuated but seem to be changing very little other than coarsening slightly over time. While this does not imply that streambottom conditions have returned to what they were before 1964, it does indicate that a great deal of resilience has returned to the watershed.

Correction to Previous Reports.—Figure 28 in Nelson et al. (1999) shows mean annual discharge for 1996 and 1999 to be similar. This was apparently due to duplication of 1996 data for 1998 in the database; in fact, 1999 mean annual discharge in 1999 was above average but not as high as 1996.

SECESH RIVER

Fine sediments in the Lake Creek/Secesh River spawning areas were generally increasing until about 1990, and have since begun to decline. In recent years, there has been relatively little timber harvest in the watershed because of concerns over chinook salmon and steelhead, and, even before publication of the Forest Plan in 1988, efforts were underway to improve watershed conditions. Reconstruction of the Burgdorf Road and reductions in grazing intensity occurred before 1988, with the former possibly causing short-term increases in streambed fines during and immediately after construction (Figure 30). After 1988, the Burgdorf Road was much improved by reconstruction, and various rehabilitative and mitigative measures were implemented pursuant to Forest Plan direction to improve fish habitat and avoid new damage to fish habitat (FP IV-41) and to apply a “high-level” of erosion mitigation on roads adjacent to streams (FP IV-73, IV-96).

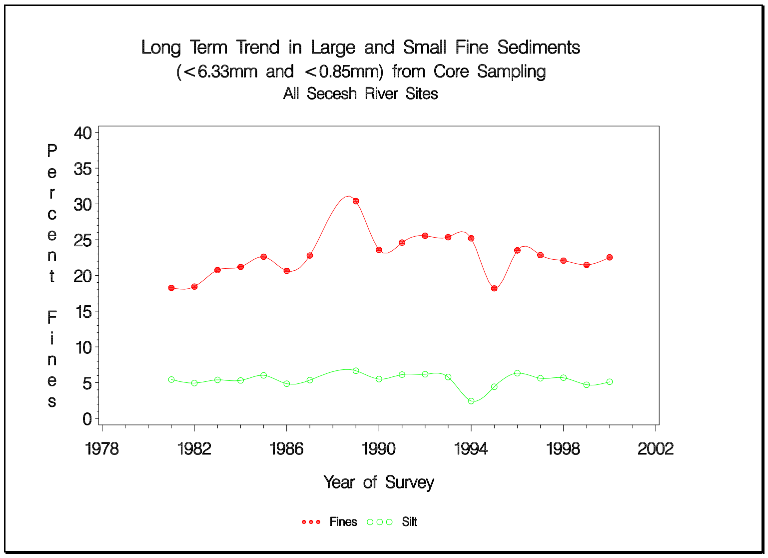

Figure 30.—Proportions of large and small fines from sediment cores in the Secesh River and Lake Creek, 1981-2000.

We recognize a continuing problem in the vicinity of Threemile and Willow Creeks and a large borrow pit adjacent to the road. This area was mined and logged at one time, and seems slow to recover, though inspection of the scatter of core sampling results (Appendix 3) suggests some leveling of the trend after about 1990; however, we have not attempted to statistically determine whether a trend can be detected. In addition, the Secesh Meadows spawning area also continues to exhibit increasing large and coarse fines. The Secesh Meadows area is difficult to monitor because of private property concerns, and land use in the area is clearly not controlled by the

Forest Service; however, here, too, it does appear that the upward trend has begun to moderate since about 1990, though annual fluctuations have very high since 1996.

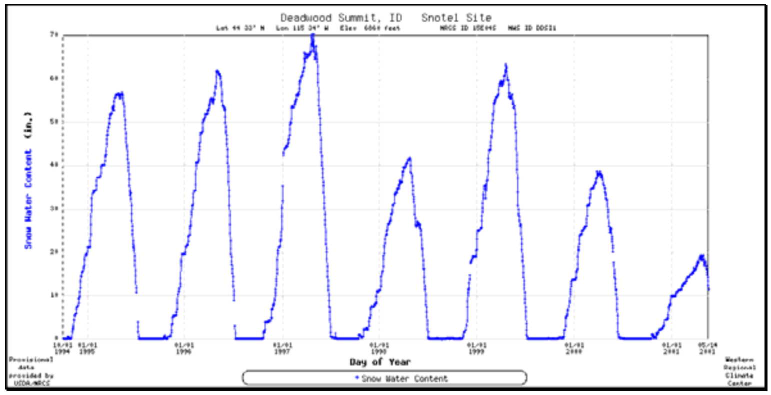

Figure 31.—Snow-water equivalence, Secesh Summit Idaho, water years 1995 to present (from USDA NRCS SNOTEL monitoring).

Although anthropogenic land disturbances have been reduced, there have been two large wildfires in the watershed since 1994. There has not, however, been any significant flooding despite these natural disturbances and high snowpacks. There are no USGS flow gages on the river or its principal tributaries, but there is a SNOTEL gage at Secesh Summit on the divide between the Secesh River and North Fork Payette River watersheds. Records from this gage (Figure 30) show that the water content of the snowpack has been high in recent years (excluding water year 2001), so we can be sure that stream discharge has been correspondingly high. Despite the cumulative effects of past and present anthropogenic disturbances, spawning conditions for anadromous fish are generally favorable and seem to be improving. An overall picture of the behavior of large and small fine sediments in the Lake Creek/Secesh River spawning areas is presented in Figure 31.

CHAMBERLAIN BASIN

Sediment trends in the Chamberlain Basin spawning areas were generally downward and somewhat steeper than the trends modeled for the either SFSR or Secesh River watersheds. As with the SFSR and Secesh River spawning areas, however, fines were higher in 1996 than in 1995 and have since dropped, so this pattern was apparently a general one. The West Fork Chamberlain Creek spawning area has been grazed fairly heavily in the past, and intragravel quality for chinook salmon embryos there is lower. In addition, there is a subdued trend toward increasing streambed coarseness, and the site has a streambed particle mixture more similar to the developed SFSR sites than either the Chamberlain Creek spawning area or most of the Lake Creek/Secesh River areas. The condition of the West Fork Chamberlain Creek spawning area shows that even Wilderness designation and relatively little development does not mean that spawning gravel conditions will be dramatically better than similar areas that have been developed.

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Appendix I: Glossary

Autocorrelation	The extent to which the error terms in a time series are correlated with one another (i.e., the observations are not independent through time). Also called "serial autocorrelation."
Autoregression	For the purposes of this report, a regression analysis technique that takes autocorrelated errors into account.
Coarse Fines	Used in this report to indicate substrate particles smaller than 4.75mm in diameter, or small fines.
Cobble	Substrate particles with major axis diameters from 45mm to 300mm. This definition does not correspond to the Wentworth scale, where cobbles range from 64mm to 256mm particle diameter.
Coarsening	Streambed condition in which the average size of the particles is getting larger.
Embeddedness	Impaction of substrate particles (principally cobbles) by fines.
Fines	Used in this report to indicate substrate particles smaller than 6.33mm, inclusive. Also called "large fines."
Fining	Streambed condition in which the bed is aggrading.
GIS	Acronym for "Geographic Information System," a computerized approach to geospatial data management, analysis, and mapping.
GMPD	Abbreviation used in this report for "geometric mean particle diameter," a statistic that provides some insight into the distribution of particle sizes.
Heteroscedasticity	Statistical condition when error variances for all observations are unequal.
Highly Significant	Used in this report to designate statistical significance at the 1% level ($P \leq 0.01$).
Large Fines	Used in this report to indicate substrate particles smaller than 6.33mm in diameter, inclusive.
Matrix Particle	A cobble particle.
OLS	Abbreviation used for the 'ordinary least squares' approach to fitting a linear regression model to time series data to distuinguish it from an approach using autocorrelation of sampling error (autoregression).
Pea Gravel	Used in this report to indicate substrate particles smaller than 9.5mm in diameter, inclusive. True pea gravel would not include the fines (depending on definition), but we have not made this distinction. This definition does not correspond to the Wentworth scale, where gravels begin at 2mm particle diameter.
Pebble Count	Substrate evaluations based on a technique described by Wolman (1954).
Sand	Used in this report to indicate coarse fines, or substrate particles smaller than 4.75mm in diameter. This definition differs from the 2mm size on the

Wentworth scale, but has been used in the fishery science literature (*e.g.*, Platts et al. 1989).

Significant Used in this report to designate statistical significance at the 5% level ($P \leq 0.05$).

Silt Used in this report to indicate small fines, or substrate particles smaller than 0.85mm in diameter. This definition differs from the 0.062mm size on the Wentworth scale, but has been selected for this report.

Small Fines Used in this report to indicate substrate particles smaller than 0.85mm in diameter.

Transformation Conversion of numeric data, often by taking the natural or base 10 logarithm, so that the data more closely approximate the desired distribution for statistical analysis.

APPENDIX II: SUPPLEMENTAL STATISTICAL TABLES

UPPER SOUTH FORK SALMON RIVER

NOTE: Various minor typographic and rounding errors have been corrected in these tables, and these should be consulted rather than tables in previous reports. In addition, more substantial corrections were required on Tables 21, 28, 31, and 32 (see *Notes* on those tables). In most cases, errors were on these tables only, not the summary tables in the body of the report.

Table 19.—Mean annual percentages of fine sediments from core sampling in the Stolle Meadows spawning area, South Fork Salmon River, 1977-2000.

	Large Fines			Coarse Fines			Small Fines			GMPD[a]		
Year	N[b]	Mean	S.E.[c]	N[b]	Mean	S.E.[c]	N[b]	Mean	S.E.[c]	N[b]	Mean	S.E.[c]
1977	40	22.2	1.1	40	18.5	0.9	40	4.5	0.3	40	19.2	0.6
1978	40	19.9	0.9	40	17.1	0.8	40	5.8	0.3	40	20.3	0.5
1979	40	23.0	1.1	40	19.2	0.9	40	6.4	0.4	40	19.1	0.6
1980	40	20.7	1.4	40	16.2	1.2	40	3.6	0.2	40	44.8	3.3
1981	40	22.7	1.0	40	18.0	0.9	40	5.3	0.4	40	38.1	2.0
1982	40	17.5	1.0	40	14.0	0.9	40	4.5	0.4	40	48.4	2.7
1983	40	22.4	1.3	40	18.8	1.1	40	4.7	0.4	40	35.9	2.6
1984	40	25.0	1.0	40	20.8	0.9	40	4.4	0.2	40	29.9	1.4
1985	40	22.7	0.7	40	18.8	0.7	40	4.5	0.3	40	33.6	1.2
1986	40	26.3	1.1	40	21.5	1.1	40	5.4	0.3	40	31.3	2.2
1987	40	27.0	1.6	40	21.5	1.3	40	5.1	0.4	40	35.1	2.3
1988	40	20.4	1.3	40	16.3	1.1	40	4.1	0.3	40	45.1	3.7
1989	40	22.7	1.1	40	17.9	0.9	40	4.6	0.2	40	39.0	1.9
1990	40	25.8	1.4	40	20.7	1.3	40	5.5	0.4	40	32.6	1.8
1991	40	26.2	1.8	40	21.0	1.7	40	5.0	0.4	40	35.1	2.4
1992	35	24.5	1.2	35	20.4	1.2	35	5.1	0.3	35	37.9	2.4
1993	20	23.4	1.3	20	19.0	1.2	20	4.6	0.4	20	36.5	2.1
1994	40	18.9	1.2	40	13.4	1.1	40	2.7	0.5	40	54.1	3.9
1995	40	26.7	1.1	40	21.8	0.9	40	5.9	0.5	40	28.2	1.5
1996	40	32.8	2.2	40	28.1	2.1	40	6.0	0.5	40	25.8	2.7
1997	40	25.5	1.7	40	20.4	1.5	40	5.6	0.5	40	35.6	2.8
1998	40	24.3	1.4	40	19.7	1.2	`40	5.4	0.4	40	36.7	3.0
1999	40	28.6	1.5	40	24.3	1.5	40	5.3	0.3	40	30.0	2.7
2000	40	25.2	1.3	40	19.4	1.2	40	4.1	0.4	40	33.3	2.1
Average	**39**	**23.9**	**1.3**	**39**	**19.5**	**1.2**	**39**	**4.9**	**0.4**	**39**	**34.4**	**2.2**

[a] GMPD - Geometric Mean Particle Diameter.
[b] N - Sample Size
[c] S.E. - Standard Error of the Mean.

Table 20.—Mean annual percentages of fine sediments from core sampling in the Dollar Creek spawning area, South Fork Salmon River, 1977-2000.

Year	Large Fines			Coarse Fines			Small Fines			GMPD[a]		
	N[b]	Mean	S.E.[c]	N[b]	Mean	S.E.[c]	N[b]	Mean	S.E.[c]	N[b]	Mean	S.E.[c]
1977	40	29.0	1.0	40	25.6	1.0	40	5.5	0.3	40	15.8	0.5
1978	40	31.1	1.0	40	27.8	0.9	40	6.7	0.3	40	14.7	0.4
1979	40	28.1	1.1	40	25.3	1.0	40	8.5	0.4	40	16.0	0.5
1980	40	27.7	1.2	40	24.3	1.1	40	4.9	0.3	40	28.3	1.4
1981	40	26.2	1.0	40	22.6	0.9	40	7.0	0.4	40	30.9	1.7
1982	40	27.5	1.0	40	23.8	0.9	40	6.3	0.3	40	29.2	1.3
1983	40	27.8	1.0	40	24.5	1.0	40	4.1	0.1	40	30.3	2.1
1984	40	26.5	1.1	40	23.0	1.0	40	3.6	0.2	40	29.1	1.4
1985	40	29.7	0.8	40	26.1	0.7	40	4.3	0.1	40	25.0	0.9
1986	40	28.7	0.9	40	24.4	0.9	40	4.5	0.2	40	28.2	1.3
1987	40	28.6	0.8	40	24.3	0.7	40	4.1	0.2	40	30.0	1.5
1988	40	26.8	1.1	40	22.3	0.9	40	4.2	0.2	40	29.6	1.4
1989	40	30.9	1.1	40	26.7	1.1	40	4.0	0.2	40	25.5	1.3
1990	40	30.2	1.0	40	24.7	0.8	40	4.7	0.3	40	23.2	1.0
1991	40	26.6	0.7	40	21.8	0.7	40	3.3	0.2	40	29.2	1.1
1992	40	26.4	1.0	40	22.8	0.9	40	4.0	0.2	40	31.0	2.0
1993	40	29.5	1.5	40	24.6	1.4	40	4.1	0.2	40	26.9	1.5
1994	40	26.0	1.4	40	19.9	1.5	40	2.5	0.4	40	39.6	3.0
1995	40	25.6	1.2	40	21.5	1.0	40	4.6	0.3	40	29.5	1.9
1996	40	27.8	0.7	40	23.9	0.7	40	5.3	0.2	40	28.3	1.1
1997	40	28.9	0.9	40	23.8	0.8	40	4.6	0.2	40	26.3	1.2
1998	40	42.7	1.8	40	37.2	1.8	40	9.6	0.5	40	15.6	1.0
1999	40	26.3	1.3	40	22.0	1.2	40	3.7	0.2	40	28.6	1.4
2000	40	28.9	1.2	40	24.1	1.2	40	1.9	0.2	40	26.1	1.1
Average	**40**	**28.6**	**1.1**	**40**	**24.5**	**1.0**	**40**	**4.8**	**0.3**	**40**	**26.5**	**1.3**

[a] GMPD - Geometric Mean Particle Diameter.
[b] N - Sample Size
[c] S.E. - Standard Error of the Mean.

Table 21.—Mean annual percentages of fine sediments from core sampling in the Poverty Flat spawning area, South Fork Salmon River, 1977-2000.

Year	Large Fines			Coarse Fines			Small Fines			GMPD[a]		
	N[b]	Mean	S.E.[c]	N[b]	Mean	S.E.[c]	N[b]	Mean	S.E.[c]	N[b]	Mean	S.E.[c]
1977	40	35.9	1.1	40	31.3	1.1	40	13.2	0.9	40	11.9	0.4
1978	40	33.7	1.2	40	29.2	1.1	40	11.1	0.8	40	12.5	0.4
1979	40	32.4	0.9	40	28.9	0.8	40	11.8	0.7	40	13.6	0.4
1980	40	29.3	0.9	40	26.4	0.8	40	6.0	0.4	40	23.2	1.1
1981	40	30.1	1.1	40	26.6	1.1	40	8.7	0.6	40	23.7	1.3
1982	40	30.4	1.3	40	26.7	1.2	40	7.5	0.4	40	23.1	1.8
1983	40	35.5	0.8	40	31.5	0.8	40	5.5	0.3	40	17.8	0.7
1984	40	28.9	1.0	40	25.3	1.0	40	4.7	0.4	40	25.2	1.4
1985	40	36.0	1.3	40	32.3	1.3	40	5.5	0.3	40	17.9	1.1
1986	40	34.1	0.9	40	29.4	0.9	40	6.0	0.4	40	22.0	1.6
1987	40	33.8	1.0	40	28.6	1.1	40	7.5	0.4	40	18.4	1.1
1988	40	30.2	1.1	40	25.2	1.0	40	4.7	0.3	40	26.6	2.0
1989	40	28.3	1.3	40	24.3	1.2	40	4.4	0.3	40	27.3	1.6
1990	40	29.8	1.1	40	25.5	1.2	40	5.4	0.3	40	25.2	1.5
1991	40	31.2	1.2	40	26.9	1.1	40	4.8	0.4	40	23.6	1.4
1992	40	31.2	0.9	40	27.1	0.9	40	7.4	0.4	40	22.1	1.4
1993	40	35.1	1.3	40	30.7	1.3	40	5.5	0.4	40	18.6	1.1
1994	40	33.4	1.3	40	26.2	1.7	40	4.3	0.8	40	25.5	2.1
1995	40	29.8	1.6	40	25.5	1.5	40	5.9	0.5	40	24.9	1.5
1996	40	35.3	1.5	40	29.7	1.5	40	5.9	0.5	40	18.2	1.2
1997	40	36.8	1.2	40	31.6	1.2	40	9.0	0.4	40	18.3	1.3
1998	40	28.0	1.1	40	23.4	1.0	40	4.2	0.2	40	26.6	1.4
2000	38	37.8	1.3	38	31.6	1.3	38	7.8	0.5	38	17.7	1.2
2001	40	30.1	2.3	40	26.1	2.2	40	2.4	0.3	40	35.7	3.7
Average	**40**	**32.4**	**1.2**	**40**	**27.9**	**1.2**	**40**	**6.6**	**0.5**	**40**	**21.7**	**1.4**

[a] GMPD - Geometric Mean Particle Diameter.
[b] N - Sample Size
[c] S.E. - Standard Error of the Mean.

Table 22.—Mean annual percentages of fine sediments from core sampling in the Glory Hole spawning area, South Fork Salmon River, 1977-2000.

Year	Large Fines			Coarse Fines			Small Fines			GMPD[a]		
	N[b]	Mean	S.E.[c]	N[b]	Mean	S.E.[c]	N[b]	Mean	S.E.[c]	N[b]	Mean	S.E.[c]
1977	40	31.8	1.0	40	28.0	1.0	40	7.0	0.5	40	13.6	0.3
1978	40	31.7	1.2	40	28.4	1.1	40	11.0	0.3	40	13.2	0.6
1979	40	32.9	1.2	40	28.8	1.1	40	6.1	0.2	40	14.1	0.5
1980	40	30.6	1.1	40	25.0	0.9	40	6.1	0.4	40	23.9	1.4
1981	40	27.2	0.9	40	24.1	0.9	40	5.0	0.4	40	25.2	1.3
1982	40	24.5	1.3	40	20.7	1.2	40	5.2	0.3	40	28.5	1.6
1983	40	24.5	1.0	40	21.4	0.9	40	4.2	0.2	40	30.1	1.5
1984	40	22.1	1.1	40	19.1	1.0	40	3.1	0.2	40	33.7	1.5
1985	40	29.0	1.3	40	25.8	1.3	40	4.0	0.2	40	25.8	1.4
1986	40	22.5	1.1	40	19.1	1.1	40	3.2	0.2	40	34.0	1.5
1987	40	28.8	1.1	40	24.2	0.9	40	5.2	0.5	40	25.6	1.2
1988	40	25.2	1.0	40	21.7	0.9	40	3.8	0.1	40	31.1	1.5
1989	40	24.1	1.1	40	19.6	1.0	40	3.7	0.2	40	30.0	1.5
1990	40	28.6	1.1	40	24.9	1.1	40	3.5	0.2	40	25.9	1.3
1991	40	23.6	1.0	40	19.9	0.9	40	3.8	0.4	40	31.8	1.3
1992	40	27.4	1.0	40	24.0	1.0	40	5.2	0.3	40	28.1	1.6
1993	40	22.8	1.1	40	18.8	1.0	40	3.8	0.2	40	32.4	2.0
1994	40	22.5	1.2	40	17.2	1.1	40	1.5	0.2	40	41.8	3.2
1995	40	34.9	1.7	40	30.7	1.7	40	5.1	0.3	40	17.5	1.2
1996	40	34.3	1.0	40	30.3	1.0	40	5.8	0.6	40	20.0	0.9
1997	40	34.2	1.0	40	29.2	1.0	40	5.9	0.3	40	19.6	0.9
1998	40	38.7	1.2	40	33.4	1.1	40	7.2	0.4	40	16.8	1.0
1999	40	35.2	1.5	40	30.7	1.6	40	6.5	0.7	40	18.9	1.0
2000	40	29.2	1.4	40	24.7	1.4	40	2.6	0.5	40	25.9	1.5
Average	**40**	**28.6**	**1.2**	**40**	**24.6**	**1.1**	**40**	**4.9**	**0.3**	**40**	**25.3**	**1.3**

[a] GMPD - Geometric Mean Particle Diameter.
[b] N - Sample Size
[c] S.E. - Standard Error of the Mean.

Table 23.—Mean annual percentages of fine sediments from core sampling in the Oxbow spawning area, South Fork Salmon River, 1977-2000.

Year	Large Fines			Coarse Fines			Small Fines			GMPD[a]		
	N[b]	Mean	S.E.[c]	N[b]	Mean	S.E.[c]	N[b]	Mean	S.E.[c]	N[b]	Mean	S.E.[c]
1977	40	35.0	1.1	40	31.4	1.0	40	7.3	0.4	40	12.7	0.4
1978	40	36.4	0.6	40	32.7	0.6	40	11.6	0.6	40	11.8	0.2
1979	40	34.9	1.0	40	31.2	1.0	40	10.1	0.5	40	12.7	0.3
1980	40	32.0	1.3	40	27.7	1.2	40	7.2	0.3	40	22.0	1.1
1981	40	31.4	0.7	40	27.5	0.7	40	8.3	0.4	40	22.0	1.0
1982	40	30.5	1.3	40	26.8	1.2	40	6.8	0.4	40	24.1	1.8
1983	40	36.2	0.9	40	31.9	0.9	40	6.3	0.3	40	19.0	1.0
1984	40	33.5	0.7	40	29.4	0.7	40	5.0	0.3	40	20.0	0.8
1985	40	36.6	0.9	40	32.4	0.8	40	5.4	0.3	40	17.0	0.7
1986	40	35.6	0.7	40	29.8	0.6	40	5.7	0.4	40	18.3	0.7
1987	40	35.5	0.7	40	30.3	0.7	40	6.6	0.3	40	18.8	0.6
1988	40	29.7	1.3	40	24.6	1.2	40	4.4	0.2	40	25.4	1.6
1989	40	30.0	1.2	40	24.9	1.1	40	5.2	0.3	40	25.6	1.5
1990	40	31.7	1.4	40	26.2	1.3	40	5.5	0.3	40	23.2	1.6
1991	40	27.1	1.1	40	21.9	0.9	40	4.6	0.3	40	26.6	1.6
1992	40	28.3	1.3	40	23.7	1.3	40	5.9	0.4	40	27.8	2.0
1993	20	21.8	1.4	20	16.7	1.1	20	3.4	0.2	20	38.0	3.2
1994	40	33.2	1.0	40	24.3	1.1	40	3.0	0.5	40	26.4	1.6
1995	40	34.1	1.2	40	27.4	1.1	40	6.1	0.3	40	19.5	1.0
1996	40	32.2	1.3	40	26.7	1.2	40	5.9	0.4	40	22.2	1.3
1997	40	36.3	0.7	40	31.6	0.7	40	7.6	0.3	40	17.1	0.5
1998	40	29.2	1.1	40	23.2	1.0	40	5.9	0.4	40	23.6	1.0
1999	40	31.3	1.5	40	25.6	1.5	40	6.8	0.5	40	22.2	1.4
2000	40	27.9	1.2	40	21.7	1.2	40	3.6	0.5	40	25.0	1.2
Average	**39**	**32.1**	**1.1**	**39**	**27.1**	**1.0**	**39**	**6.2**	**0.4**	**39**	**21.7**	**1.2**

[a] GMPD - Geometric Mean Particle Diameter.
[b] N - Sample Size
[c] S.E. - Standard Error of the Mean.

Table 24.—Mean annual percentages of fine sediments from core sampling in the Ice Hole spawning area, Johnson Creek, 1977-2000.

Year	Large Fines			Coarse Fines			Small Fines			GMPD[a]		
	N[b]	Mean	S.E.[c]	N[b]	Mean	S.E.[c]	N[b]	Mean	S.E.[c]	N[b]	Mean	S.E.[c]
1977	40	24.4	0.8	40	21.8	0.8	40	4.8	0.3	40	17.2	0.5
1978	40	25.5	0.7	40	23.1	0.7	40	6.5	0.3	40	16.4	0.4
1979	40	23.1	0.7	40	19.5	0.6	40	6.0	0.2	40	18.3	0.3
1980	40	25.4	1.1	40	22.3	1.1	40	5.5	0.3	40	29.5	1.6
1981	40	25.9	0.8	40	22.8	0.8	40	4.6	0.2	40	26.3	1.0
1982	40	27.3	1.0	40	24.4	1.0	40	4.7	0.3	40	25.4	0.9
1983	40	27.9	1.1	40	24.9	1.0	40	4.2	0.3	40	25.5	1.2
1984	40	27.9	0.9	40	25.0	0.9	40	3.3	0.2	40	23.7	0.7
1985	40	32.3	0.9	40	29.4	0.9	40	3.7	0.2	40	20.7	1.1
1986	40	31.6	1.0	40	28.4	0.9	40	4.2	0.3	40	21.5	1.0
1987	40	27.9	1.0	40	24.6	1.1	40	5.2	0.2	40	26.7	1.8
1988	40	26.1	1.2	40	22.7	1.2	40	4.8	0.3	40	31.7	2.4
1989	40	25.7	0.7	40	21.9	0.7	40	4.2	0.2	40	28.5	1.2
1990	40	23.7	0.9	40	20.9	0.9	40	3.4	0.2	40	29.9	1.8
1991	40	28.3	1.1	40	25.0	1.1	40	4.3	0.2	40	26.9	1.8
1992	40	26.2	1.4	40	23.4	1.3	40	3.5	0.3	40	32.5	2.9
1993	40	30.4	1.0	40	26.2	0.9	40	4.2	0.2	40	23.4	1.4
1994	40	30.7	0.9	40	26.8	1.0	40	2.9	0.4	40	28.0	1.8
1995	40	33.3	0.8	40	29.2	0.8	40	5.4	0.3	40	18.8	0.7
1996	40	28.5	1.4	40	24.3	1.2	40	3.7	0.2	40	29.5	2.8
1997	40	27.8	0.6	40	23.6	0.6	40	5.3	0.2	40	26.1	0.9
1998	40	26.9	1.0	40	22.9	0.9	40	5.6	0.3	40	27.5	1.8
1999	40	26.9	0.9	40	23.0	0.9	40	4.6	0.3	40	27.4	1.4
2000	40	23.0	1.6	40	19.2	1.6	40	3.5	1.5	40	40.8	2.4
Average	40	27.4	1.0	40	24.0	1.0	40	4.5	0.3	40	25.9	1.4

[a] GMPD - Geometric Mean Particle Diameter.
[b] N - Sample Size
[c] S.E. - Standard Error of the Mean.

SECESH RIVER

Table 25.—Mean annual percentages of fine sediments from core sampling in the Corduroy Junction spawning area, Lake Creek, 1977-2000.

Year	Large Fines			Coarse Fines			Small Fines			GMPD[a]		
	N[b]	Mean	S.E.[c]	N[b]	Mean	S.E.[c]	N[b]	Mean	S.E.[c]	N[b]	Mean	S.E.[c]
1981	40	16.3	1.1	40	9.4	0.6	40	5.4	0.6	40	48.0	3.4
1982	40	14.1	0.9	40	9.2	0.6	40	2.9	0.3	40	47.2	3.3
1983	40	16.8	0.9	40	11.0	0.7	40	3.9	0.2	40	47.7	3.3
1984	40	19.5	1.3	40	12.9	1.0	40	4.3	0.3	40	37.6	3.6
1985	40	22.1	1.0	40	14.4	0.8	40	5.7	0.4	40	32.8	1.9
1986	NA[a]	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
1987	40	22.3	1.6	40	14.9	1.0	40	5.2	0.8	40	37.7	4.3
1988	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
1989	38	33.1	1.4	38	21.9	1.4	38	8.5	0.5	38	19.4	1.2
1990	40	23.7	1.5	40	16.1	1.3	40	5.1	0.3	40	28.6	2.1
1991	37	28.2	1.3	37	19.6	1.1	37	6.2	0.3	37	25.0	1.7
1992	40	28.5	1.2	40	18.1	0.9	40	7.4	0.9	40	24.4	1.7
1993	40	26.8	1.6	40	18.5	1.5	40	6.5	0.4	40	26.8	1.8
1994	NA[a]	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
1995	40	17.7	1.9	40	12.6	1.6	40	3.2	0.3	40	43.2	3.7
1996	40	21.8	1.6	40	13.9	0.8	40	5.6	0.8	40	34.3	3.1
1997	40	23.9	1.7	40	16.8	1.1	40	4.8	0.6	40	30.2	2.4
1998	40	20.9	1.4	40	14.0	1.0	40	4.7	0.4	40	35.7	3.8
1999	40	19.4	1.3	40	13.8	1.0	40	3.6	0.3	40	39.6	3.9
2000	38	23.1	1.6	38	16.1	1.4	38	5.0	0.3	38	35.0	3.4
Average	40	22.2	1.4	40	14.9	1.0	40	5.2	0.5	40	34.9	2.9

[a] GMPD - Geometric Mean Particle Diameter.
[b] N - Sample Size
[c] S.E. - Standard Error of the Mean.
[d] NA – Not Available

Table 26.—Mean annual percentages of fine sediments from core sampling in the Threemile Creek spawning area, Lake Creek, 1977-2000.

Year	Large Fines			Coarse Fines			Small Fines			GMPD[a]		
	N[b]	Mean	S.E.[c]	N[b]	Mean	S.E.[c]	N[b]	Mean	S.E.[c]	N[b]	Mean	S.E.[c]
1981	40	25.8	1.1	40	13.8	0.6	40	9.4	0.6	40	22.9	2.2
1982	40	24.7	1.0	40	13.1	0.6	40	9.0	0.6	40	23.0	1.5
1983	40	28.9	1.2	40	17.1	0.9	40	9.1	0.5	40	19.7	1.2
1984	40	28.8	1.0	40	15.7	0.6	40	9.7	0.6	40	17.7	0.9
1985	40	28.0	1.5	40	15.0	0.9	40	10.0	0.6	40	19.6	1.6
1986	NA[a]	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
1987	30	29.2	1.6	30	16.7	1.1	30	9.3	0.6	30	19.4	1.7
1988	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
1989	40	31.7	1.3	40	19.4	1.0	40	9.1	0.4	40	18.0	1.6
1990	40	27.2	1.4	40	14.8	0.9	40	9.6	0.8	40	18.0	0.9
1991	39	30.8	0.9	39	17.1	0.8	39	10.8	0.6	39	15.8	0.6
1992	40	34.9	1.5	40	21.6	1.1	40	10.1	0.8	40	13.8	0.7
1993	40	32.6	1.3	40	20.0	1.4	40	10.2	0.6	40	15.8	0.8
1994	10	57.5	4.4	10	43.9	4.9	10	11.1	1.5	10	7.3	1.0
1995	40	23.2	1.8	40	12.4	1.2	40	8.6	0.8	40	30.7	3.4
1996	40	30.0	2.1	40	13.6	0.9	40	12.8	1.5	40	18.9	1.8
1997	40	35.9	2.6	40	19.1	1.4	40	13.1	1.5	40	16.1	1.5
1998	40	31.4	1.9	40	17.3	1.0	40	10.9	1.0	40	18.2	1.6
1999	40	28.8	1.8	40	17.7	1.2	40	7.8	0.6	40	20.8	1.9
2000	40	30.4	1.3	40	19.8	1.1	40	7.9	0.4	40	18.9	1.1
Average	***38***	***31.1***	***1.7***	***38***	***18.2***	***1.2***	***38***	***9.9***	***0.8***	***38***	***18.6***	***1.4***

[a] GMPD - Geometric Mean Particle Diameter.
[b] N - Sample Size
[c] S.E. - Standard Error of the Mean.
[d] NA – Not Available

Table 27.—Mean annual percentages of fine sediments from core sampling in the Burgdorf spawning area, Lake Creek, 1977-2000.

Year	Large Fines			Coarse Fines			Small Fines			GMPD[a]		
	N[b]	Mean	S.E.[c]	N[b]	Mean	S.E.[c]	N[b]	Mean	S.E.[c]	N[b]	Mean	S.E.[c]
1981	40	19.4	1.0	40	12.8	0.7	40	4.5	0.3	40	39.5	2.6
1982	40	20.4	1.1	40	13.4	0.7	40	4.9	0.3	40	38.3	2.9
1983	40	20.8	1.1	40	13.4	0.8	40	5.4	0.3	40	41.1	3.3
1984	40	19.2	1.1	40	12.3	0.8	40	4.4	0.3	40	38.0	2.5
1985	40	22.0	0.9	40	13.9	0.7	40	5.6	0.3	40	33.3	2.1
1986	NA[a]	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
1987	40	21.6	1.4	40	14.2	1.1	40	4.7	0.4	40	39.1	3.6
1988	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
1989	39	29.0	1.3	39	22.8	1.3	39	3.3	0.7	39	23.0	1.6
1990	40	19.6	1.5	40	12.7	1.2	40	4.3	0.4	40	39.4	3.2
1991	39	20.4	1.4	39	13.5	1.1	39	4.5	0.3	39	40.1	3.2
1992	40	19.8	1.1	40	13.6	0.9	40	4.4	0.3	40	41.5	2.4
1993	30	21.5	1.2	40	15.7	1.1	40	3.6	0.3	40	38.3	3.1
1994	30	21.0	1.3	30	14.4	0.9	30	3.7	0.4	30	37.9	2.8
1995	40	14.2	1.3	40	9.3	1.0	40	3.0	0.3	40	55.3	5.6
1996	40	16.8	1.0	40	10.3	0.7	40	3.8	0.3	40	40.7	3.4
1997	40	18.5	0.9	40	12.3	0.7	40	3.8	0.2	40	36.2	2.3
1998	40	16.7	1.4	40	11.2	1.0	40	3.3	0.4	40	54.1	5.9
1999	40	18.5	1.5	40	12.7	1.1	40	3.8	0.3	40	47.4	4.5
2000	40	19.6	1.0	40	13.0	0.8	40	4.2	0.2	40	40.1	2.6
Average	***39***	***19.9***	***1.2***	***39***	***13.4***	***0.9***	***39***	***4.2***	***0.3***	***39***	***40.2***	***3.2***

[a] GMPD - Geometric Mean Particle Diameter.
[b] N - Sample Size
[c] S.E. - Standard Error of the Mean.
[d] NA – Not Available

Table 28.—Mean annual percentages of fine sediments from core sampling in the Secesh Meadows spawning area, Secesh River, 1977-2000.

	Large Fines			Coarse Fines			Small Fines			GMPD[a]		
Year	**N[b]**	**Mean**	**S.E.[c]**	**N[b]**	**Mean**	**S.E.[c]**	**N[b]**	**Mean**	**S.E.[c]**	**N[b]**	**Mean**	**S.E.[c]**
1981	40	14.2	0.6	40	8.6	0.5	40	4.1	0.2	40	48.9	2.4
1982	40	17.9	0.9	40	11.8	0.6	40	4.4	0.2	40	38.2	2.8
1983	40	18.9	0.8	40	12.6	0.6	40	4.4	0.3	40	40.7	2.3
1984	40	18.6	1.1	40	12.6	0.7	40	4.0	0.3	40	36.4	2.9
1985	40	21.2	1.2	40	14.3	0.9	40	4.9	0.3	40	36.5	2.5
1986	40	20.6	1.0	40	13.8	0.8	40	4.8	0.3	40	38.6	2.6
1987	40	21.2	1.1	40	14.4	0.8	40	4.9	0.3	40	40.4	2.7
1988	NA[a]	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
1989	40	27.2	1.0	40	19.3	0.9	40	5.6	0.4	40	26.8	1.4
1990	40	22.7	1.1	40	15.7	0.8	40	4.9	0.4	40	33.7	2.0
1991	40	23.0	1.0	40	16.4	0.8	40	4.8	0.3	40	32.5	2.1
1992	40	25.2	1.0	40	17.0	0.8	40	4.6	0.3	40	29.3	1.9
1993	40	24.0	0.9	40	17.1	0.8	40	4.6	0.2	40	30.5	1.6
1994	40	24.2	0.9	40	17.6	0.8	40	3.9	0.3	40	32.8	1.9
1995	23	16.8	1.5	23	11.4	1.2	23	3.4	0.4	23	43.7	4.4
1996	20	28.0	1.1	20	19.5	1.0	20	6.4	0.4	20	25.7	1.6
1997	40	15.5	0.8	40	11.1	0.6	40	2.7	0.2	40	47.2	2.0
1998	20	19.3	1.5	20	13.0	1.1	20	4.5	0.4	20	43.3	4.4
1999	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
2000	20	18.3	1.5	20	13.0	1.2	20	3.9	0.4	20	42.5	3.9
Average	**36**	**20.9**	**1.1**	**36**	**14.4**	**0.8**	**36**	**4.5**	**0.3**	**36**	**37.1**	**2.5**

[a] GMPD - Geometric Mean Particle Diameter.
[b] N - Sample Size
[c] S.E. - Standard Error of the Mean.
[d] NA – Not Available

Table 29.—Mean annual percentages of fine sediments from core sampling in the Chinook Campground spawning area, Secesh River, 1977-2000.

	Large Fines			Coarse Fines			Small Fines			GMPD[a]		
Year	**N[b]**	**Mean**	**S.E.[c]**	**N[b]**	**Mean**	**S.E.[c]**	**N[b]**	**Mean**	**S.E.[c]**	**N[b]**	**Mean**	**S.E.[c]**
1981	40	15.5	0.7	40	10.0	0.5	40	3.7	0.2	40	40.3	1.8
1982	40	15.1	0.5	40	9.8	0.4	40	3.6	0.1	40	46.4	2.0
1983	40	18.4	0.9	40	12.6	0.7	40	4.1	0.3	40	40.9	2.2
1984	40	19.8	0.8	40	13.7	0.8	40	4.1	0.2	40	36.8	2.0
1985	40	19.7	0.8	40	13.5	0.6	40	4.1	0.1	40	37.7	1.7
1986	NA[a]	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
1987	40	21.2	1.3	40	15.2	1.0	40	3.9	0.3	40	38.5	3.9
1988	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
1989	38	31.1	1.1	38	21.5	1.0	38	6.9	0.2	38	21.6	1.3
1990	40	24.7	1.0	40	19.1	0.9	40	3.6	0.2	40	29.6	1.6
1991	40	20.8	1.1	40	14.1	0.8	40	4.4	0.3	40	36.3	2.0
1992	40	19.4	1.1	40	12.9	0.8	40	4.4	0.3	40	44.5	2.8
1993	40	21.0	0.9	40	15.0	0.7	40	3.5	0.2	40	35.9	2.3
1994	40	23.2	1.1	40	16.2	1.0	40	4.3	0.2	40	34.2	2.7
1995	40	18.6	1.7	40	13.3	1.4	40	3.6	0.3	40	50.6	5.2
1996	40	23.1	1.3	40	17.7	1.1	40	3.2	0.2	40	37.2	2.9
1997	40	20.5	1.2	40	14.2	1.0	40	3.8	0.2	40	40.6	2.8
1998	40	20.6	1.4	40	13.9	1.2	40	4.4	0.3	40	44.0	3.5
1999	40	19.2	1.6	40	13.7	1.3	40	3.7	0.3	40	45.8	4.3
2000	40	19.2	1.2	40	13.3	1.1	40	4.1	0.3	40	43.4	3.1
Average	**40**	**20.6**	**1.1**	**40**	**14.4**	**0.9**	**40**	**4.1**	**0.2**	**40**	**39.1**	**2.7**

[a] GMPD - Geometric Mean Particle Diameter.
[b] N - Sample Size
[c] S.E. - Standard Error of the Mean.
[d] NA – Not Available

Chamberlain Basin

Table 30.—Mean annual percentages of fine sediments from core sampling in the Chamberlain Creek spawning area, Chamberlain Basin, 1981-2000.

Year	Large Fines			Coarse Fines			Small Fines			GMPD[a]		
	N[b]	Mean	S.E.[c]	N[b]	Mean	S.E.[c]	N[b]	Mean	S.E.[c]	N[b]	Mean	S.E.[c]
1981	40	24.6	1.4	40	15.0	0.9	40	7.0	0.5	40	30.4	2.5
1982	NA[a]	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
1983	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
1984	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
1985	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
1986	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
1987	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
1988	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
1989	37	31.8	1.0	37	22.7	0.8	37	5.8	0.3	37	23.3	1.1
1990	40	28.6	1.0	40	20.8	0.7	40	4.7	0.2	40	28.4	1.4
1991	40	26.4	1.0	40	18.4	0.8	40	5.1	0.2	40	33.5	1.9
1992	40	28.5	1.3	40	19.9	0.9	40	5.7	0.3	40	28.7	2.0
1993	40	21.9	0.9	40	17.1	0.8	40	2.8	0.3	40	42.2	2.0
1994	40	22.4	1.5	40	15.5	1.0	40	4.4	0.5	40	41.3	3.5
1995	40	16.9	1.4	40	12.8	1.1	40	2.3	0.2	40	61.5	5.1
1996	40	23.9	1.2	40	18.5	1.0	40	3.0	0.1	40	39.6	2.6
1997	40	15.7	1.1	40	11.3	0.9	40	2.3	0.2	40	55.6	4.1
1998	40	13.9	1.2	40	9.6	0.9	40	2.6	0.2	40	68.8	6.2
1999	40	17.2	1.3	40	12.4	1.0	40	2.7	0.2	40	60.0	4.6
2000	40	19.8	1.3	40	15.0	1.0	40	3.1	0.2	40	52.4	4.4
Average	**40**	**22.4**	**1.2**	**40**	**16.1**	**0.9**	**40**	**4.0**	**0.3**	**40**	**43.5**	**3.2**

[a] GMPD - Geometric Mean Particle Diameter.
[b] N - Sample Size
[c] S.E. - Standard Error of the Mean.
[d] NA – Not Available
NOTE: This table was misidentified as being Chinook Campground in Nelson et al. (1999).

Table 31.—Mean annual percentages of fine sediments from core sampling in the Chinook Campground spawning area, Secesh River, 1991-2000.

Year	Large Fines			Coarse Fines			Small Fines			GMPD[a]		
	N[b]	Mean	S.E.[c]	N[b]	Mean	S.E.[c]	N[b]	Mean	S.E.[c]	N[b]	Mean	S.E.[c]
1991	38	29.0	1.3	38	17.9	0.9	38	8.4	0.4	38	23.2	1.5
1992	40	31.9	1.1	40	21.0	0.9	40	8.3	0.4	40	19.5	1.1
1993	40	31.4	1.3	40	21.3	1.1	40	6.9	0.5	40	20.9	1.2
1994	40	25.9	1.0	40	18.1	0.9	40	5.4	0.3	40	23.3	1.1
1995	40	25.1	1.3	40	12.8	1.1	40	6.0	0.7	40	26.0	2.0
1996	40	34.2	0.9	40	24.6	0.7	40	6.6	0.4	40	18.4	0.4
1997	40	28.7	1.1	40	19.3	0.9	40	6.3	0.2	40	22.6	1.3
1998	40	30.6	0.8	40	21.9	0.7	40	5.4	0.2	40	20.4	1.0
1999	40	31.5	1.2	40	22.5	1.0	40	6.1	0.3	40	20.3	1.3
2000	40	33.4	0.8	40	23.1	0.8	40	7.4	0.4	40	18.6	0.9
Average	**40**	**30.2**	**1.1**	**40**	**20.3**	**0.9**	**40**	**6.7**	**0.4**	**40**	**21.3**	**1.2**

[a] GMPD - Geometric Mean Particle Diameter.
[b] N - Sample Size
[c] S.E. - Standard Error of the Mean.
NOTE: This table was misidentified as being Chinook Campground in Nelson et al. (1999). Data from 1989 and 1990 have been eliminated (see text).

Appendix III: Supplemental Time Series Graphs

Upper South Fork Salmon River

Stolle Meadows

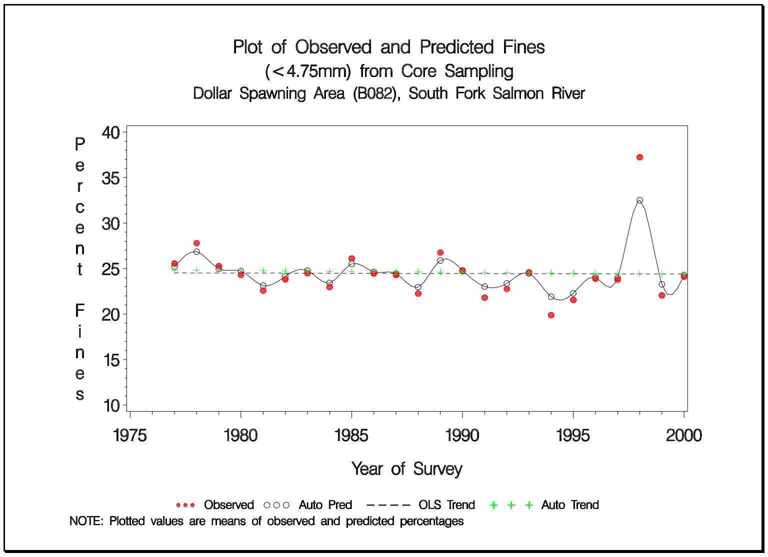

Figure 32.—Time trends in the coarse fine sediments in Stolle Meadows spawning area, upper SFSR, 1977-2000.

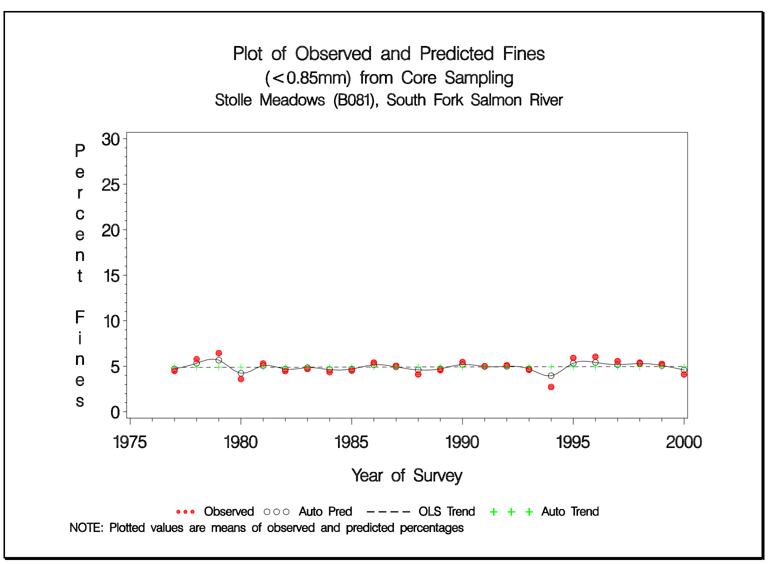

Figure 33.—Time trends in small fine sediments in the Stolle Meadows spawning area, upper SFSR, 1977-2000.

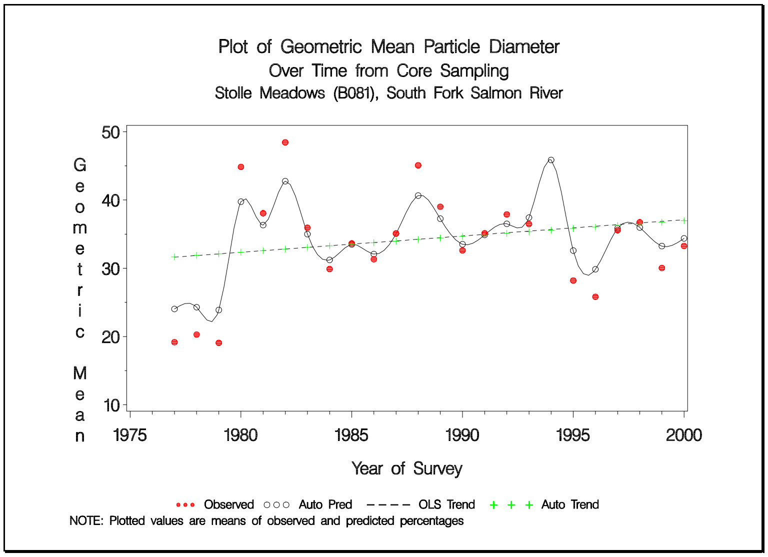

Figure 34.—Time trends in geometric mean particle diameter in the Stolle Meadows spawning area, upper SFSR, 1977-2000.

Dollar Creek

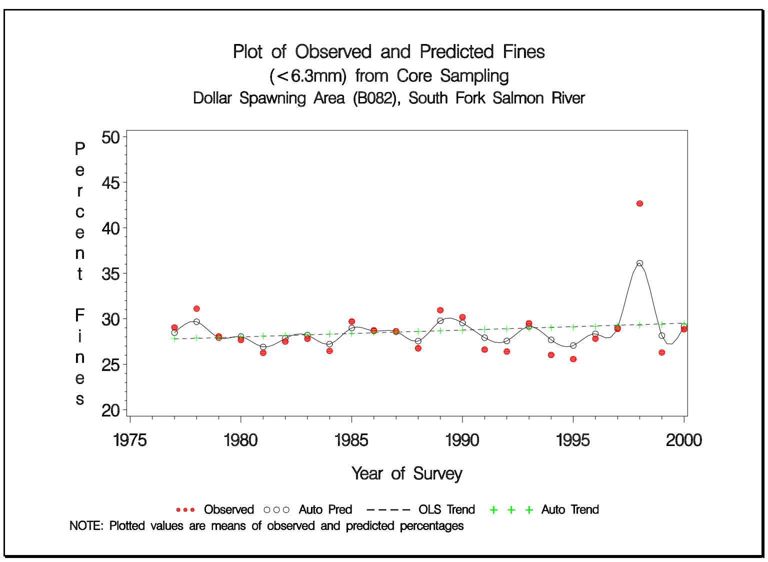

Figure 35.—Time trends in large fine sediments in the Dollar Creek spawning area, upper SFSR, 1977-2000.

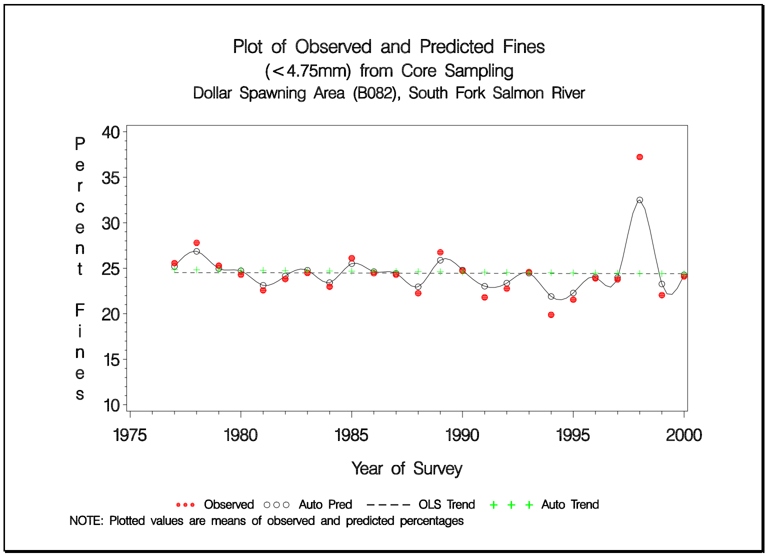

Figure 36.—Time trends in coarse fine sediments in the Dollar Creek spawning area, upper SFSR, 1977-2000.

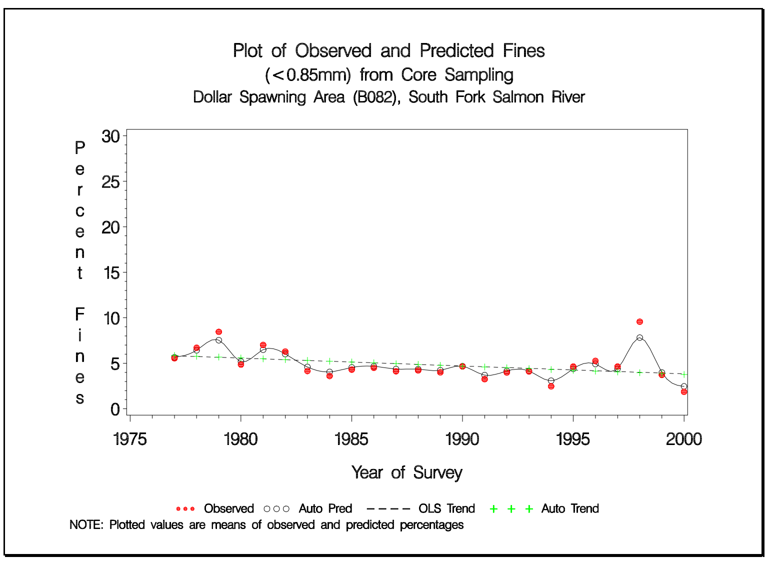

Figure 37.—Time trends in small fine sediments in the Dollar Creek spawning area, upper SFSR, 1977-2000.

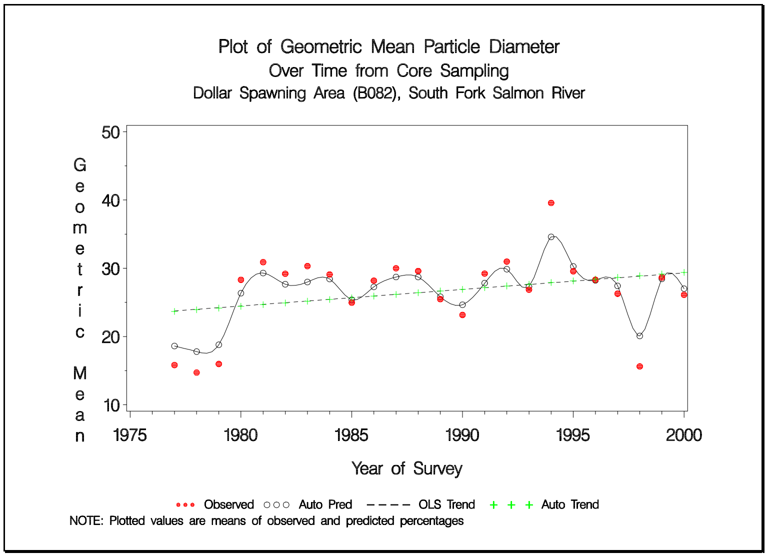

Figure 38.—Time trends in geometric mean particle diameter in the Dollar Creek spawning area, upper SFSR, 1977-2000.

Poverty Flat

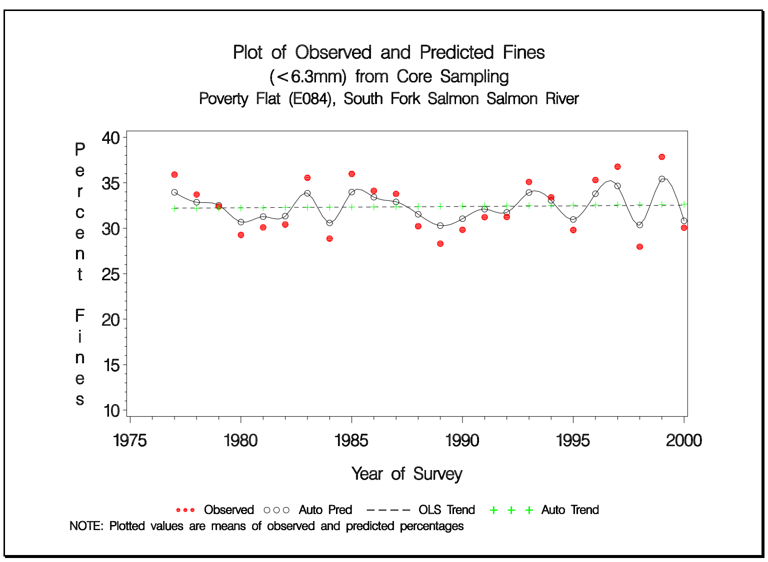

Figure 39.—Time trends in large fine sediments in the Poverty Flat spawning area, upper SFSR, 1977-2000.

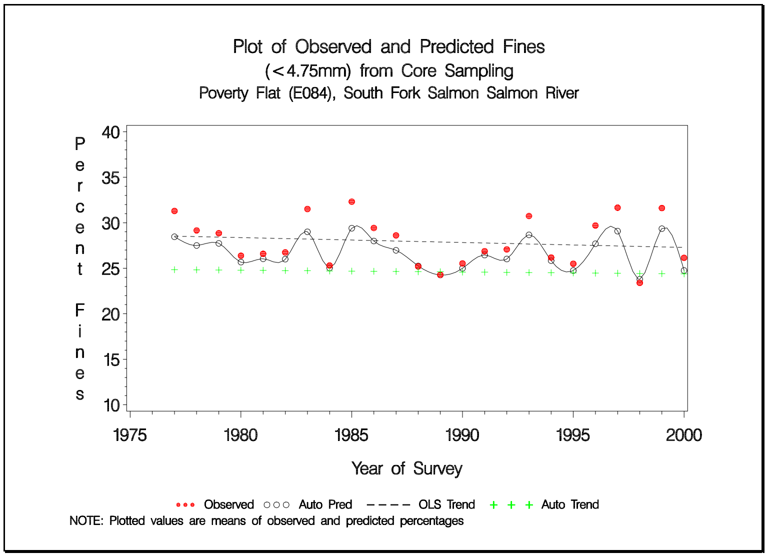

Figure 40.—Time trends in coarse fine sediments in the Poverty Flat spawning area, upper SFSR, 1977-2000 (NOTE: The autoregression trend line clearly appears incorrect, but the cause of this is unknown at this time).

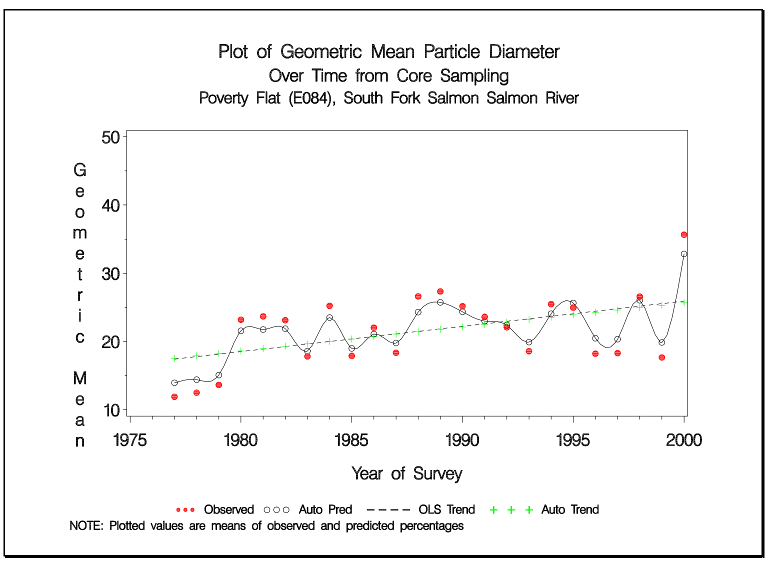

Figure 41.—Time trends in geometric mean particle diameter in the Poverty Flat spawning area, upper SFSR, 1977-2000.

Glory Hole

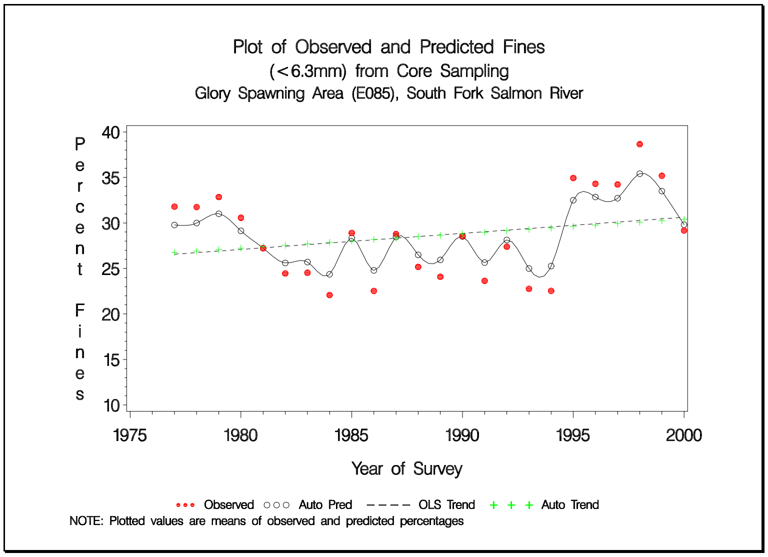

Figure 42.—Time trends in large fine sediments in the Glory Hole spawning area, upper SFSR, 1977-2000.

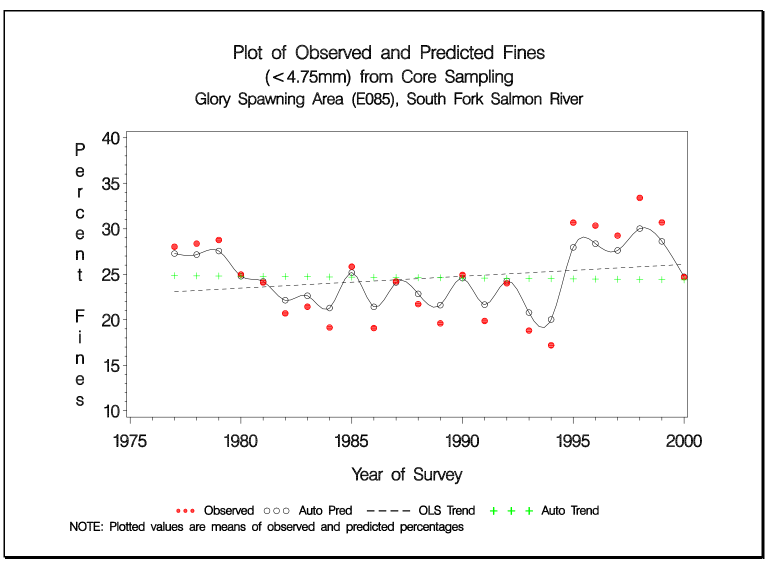

Figure 43.—Time trends in coarse fine sediments in the Glory Hole spawning area, upper SFSR, 1977-2000.

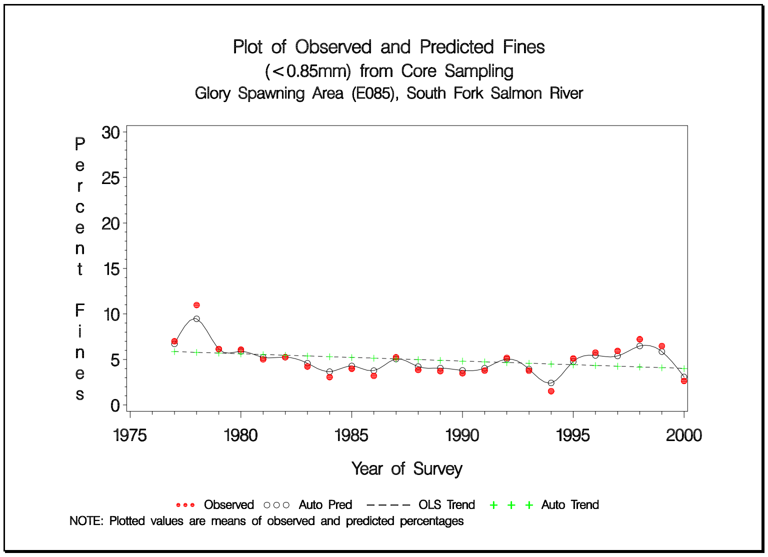

Figure 44.—Time trends in small fine sediments in the Glory Hole Flat spawning area, upper SFSR, 1977-2000.

The Oxbow

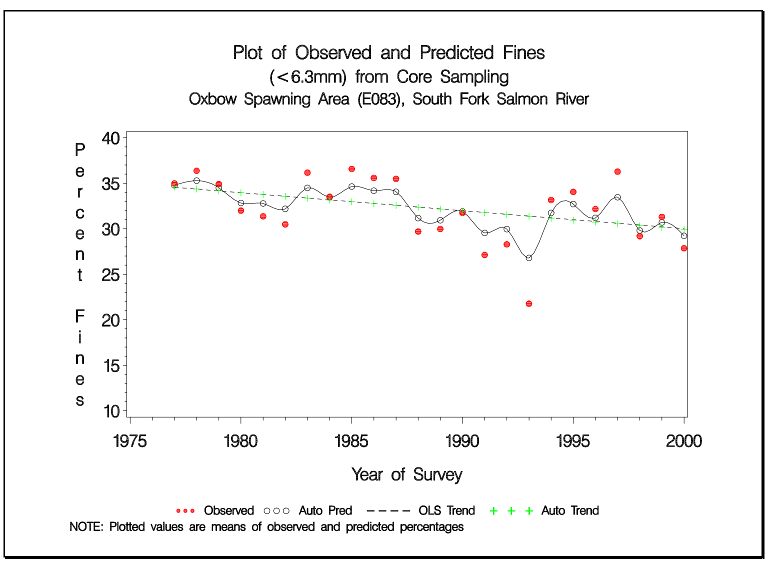

Figure 45.—Time trends in large fine sediments in the Oxbow spawning area, upper SFSR, 1977-2000.

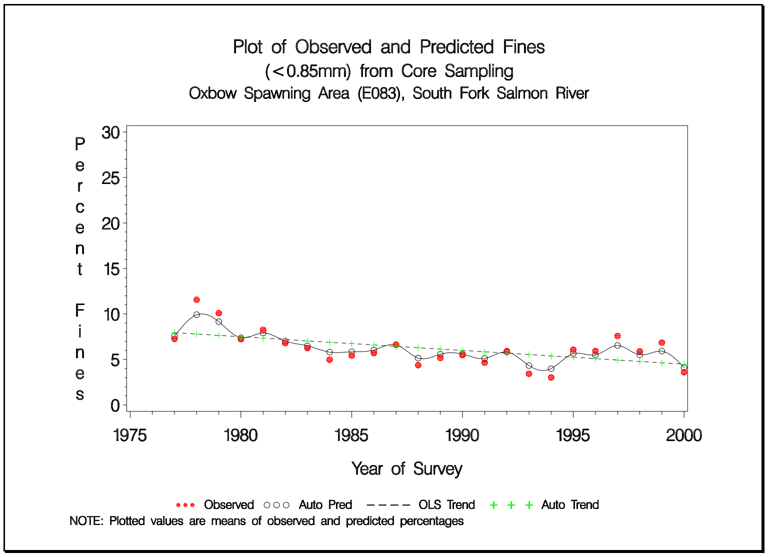

Figure 46.—Time trends in small fine sediments in the Oxbow spawning area, upper SFSR, 1977-2000.

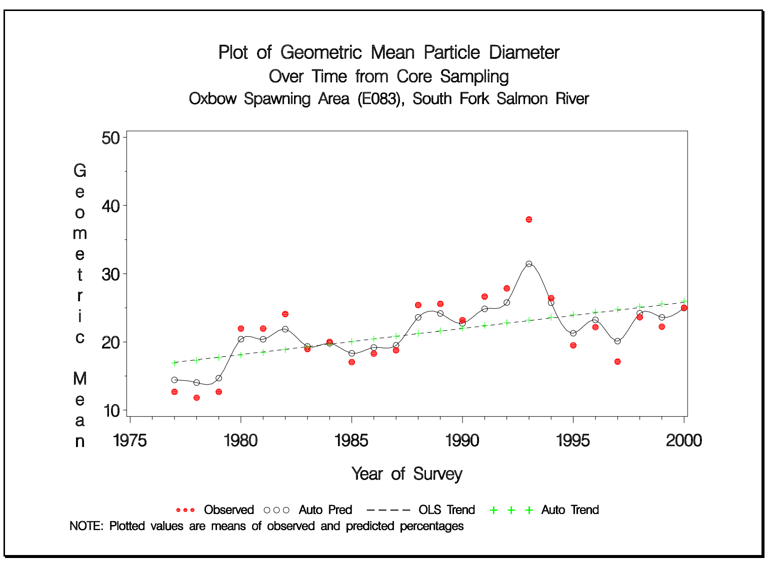

Figure 47.—Time trends in geometric mean particle diameter in the Oxbow spawning area, upper SFSR, 1977-2000.

Ice Hole

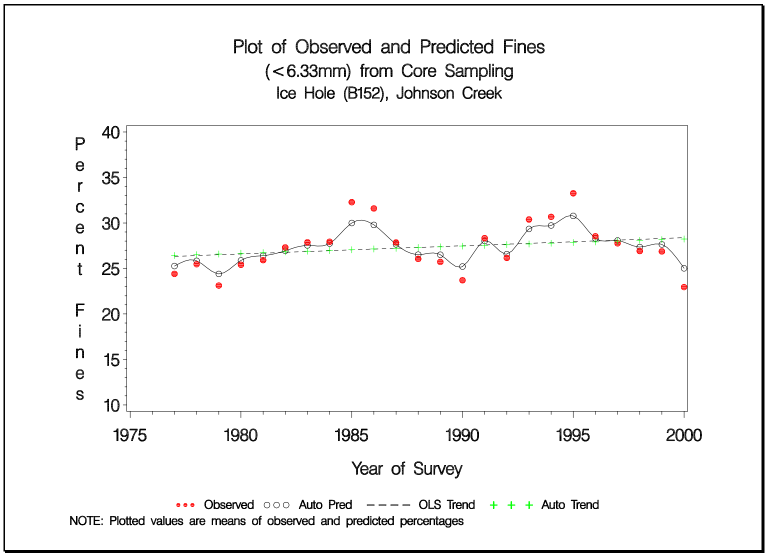

Figure 48.—Time trends in large fine sediments in the Ice Hole spawning area, upper SFSR, 1977-2000.

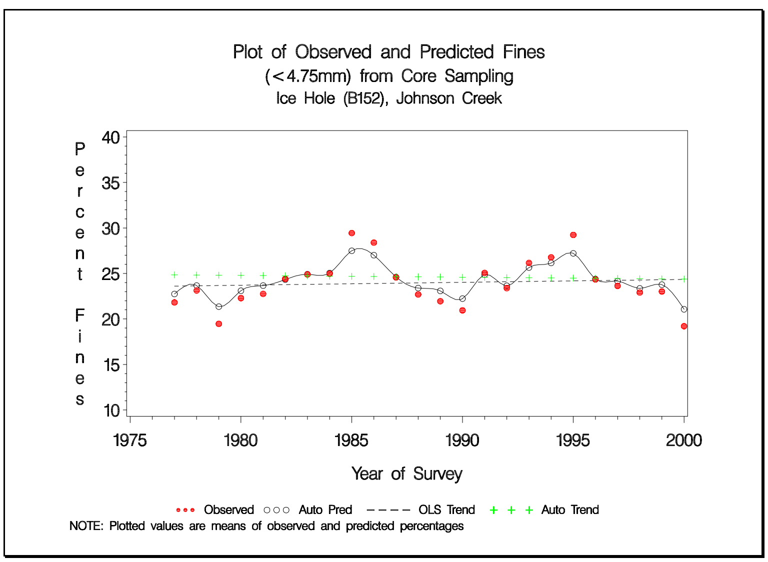

Figure 49.—Time trends in coarse fine sediments in the Ice Hole spawning area, upper SFSR, 1977-2000.

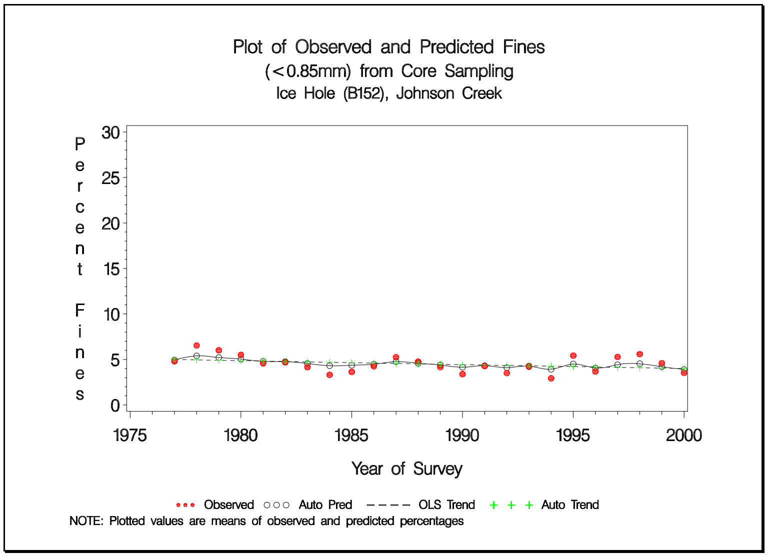

Figure 50.—Time trends in coarse fine sediments in the Ice Hole spawning area, upper SFSR, 1977-2000.

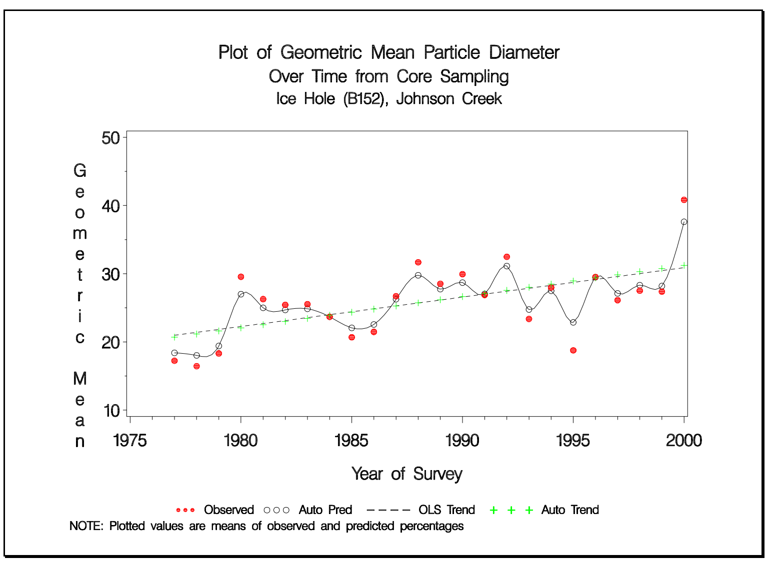

Figure 51.—Time trends in geometric mean particle diameter in the Ice Hole spawning area, upper SFSR, 1977-2000.

Corduroy Junction

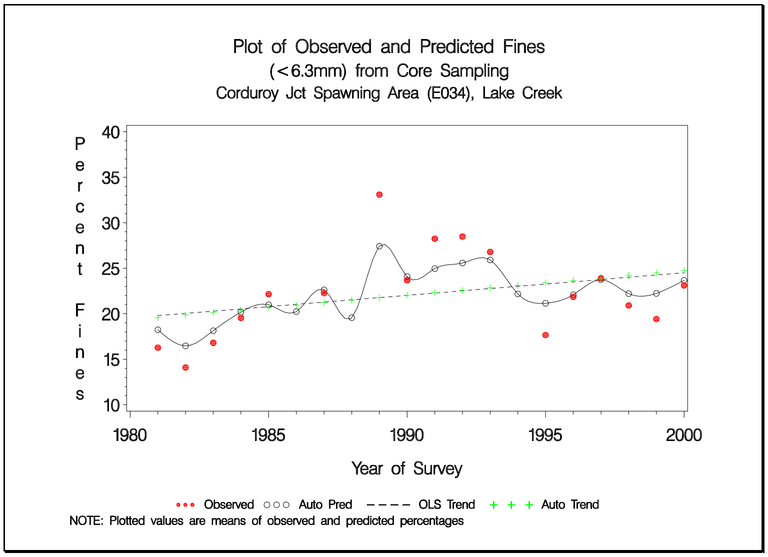

Figure 52.—Time trends in large fine sediments in the Corduroy Junction spawning area, Lake Creek, 1981-2000.

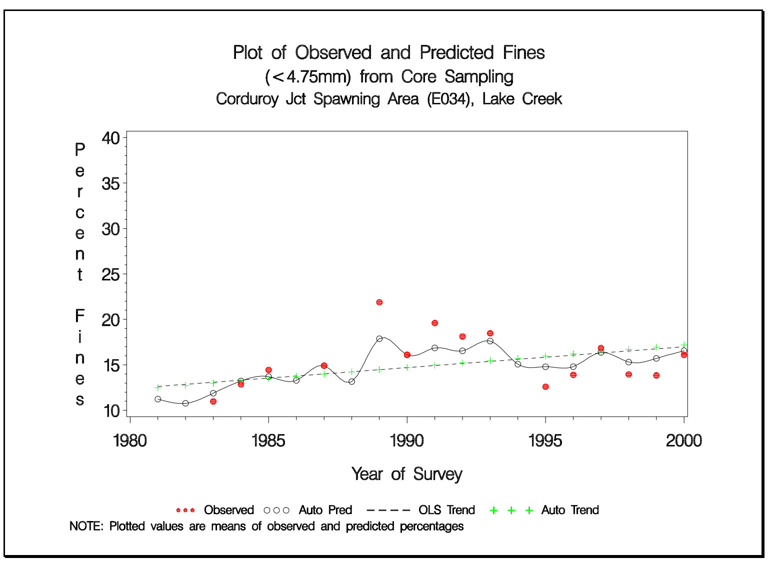

Figure 53.—Time trends in coarse fine sediments in the Corduroy Junction spawning area, Lake Creek, 1981-2000.

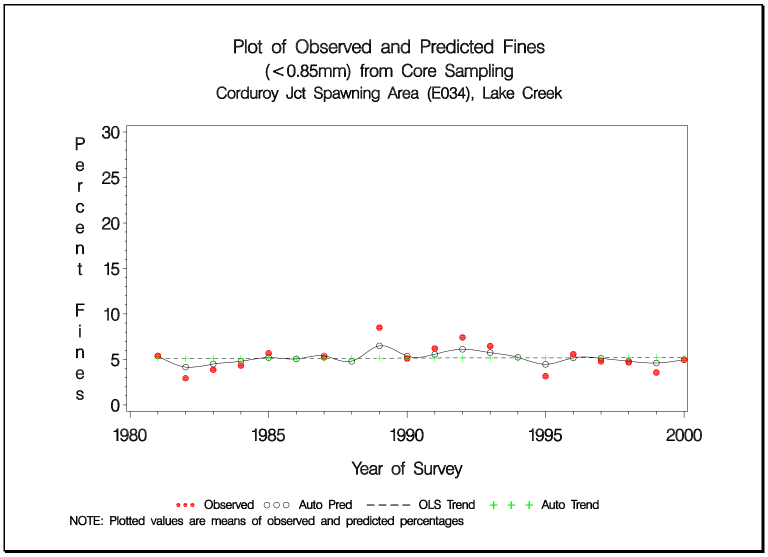

Figure 54.—Time trends in small fine sediments in the Corduroy Junction spawning area, Lake Creek, 1981-2000.

Threemile Creek

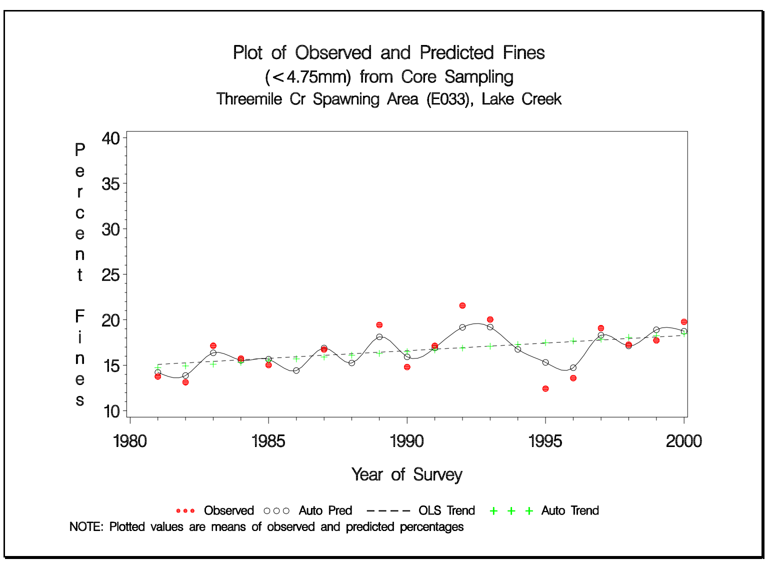

Figure 55.—Time trends in coarse fine sediments in the Threemile Creek spawning area, Lake Creek, 1977-2000.

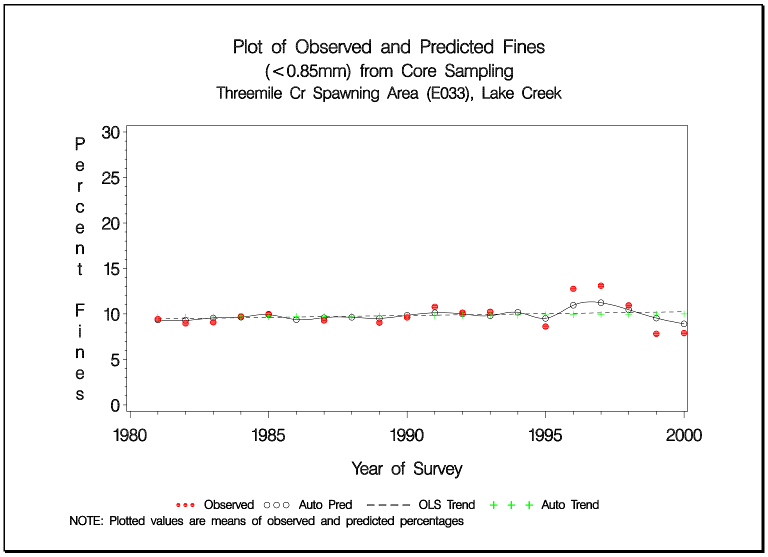

Figure 56.—Time trends in small fine sediments in the Threemile Creek spawning area, Lake Creek, 1981-2000.

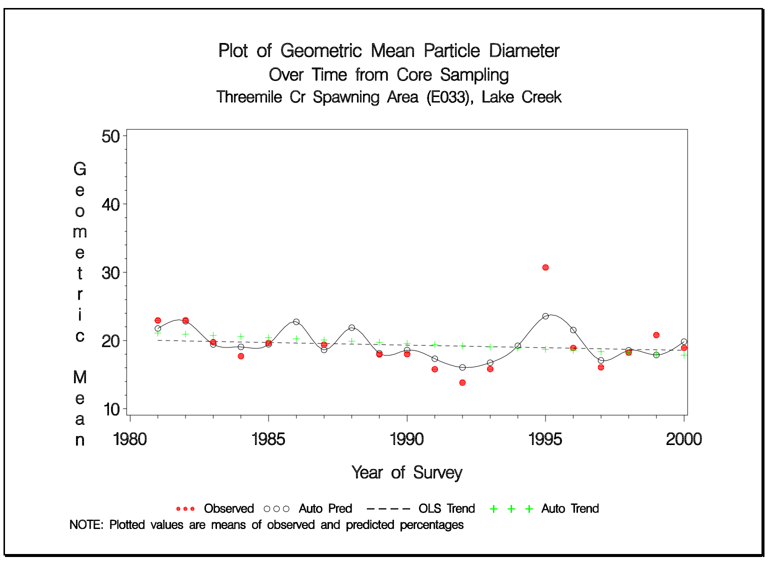

Figure 57.—Time trends in geometric mean particle diameter in the Threemile Creek spawning area, Lake Creek, 1977-2000.

Burgdorf

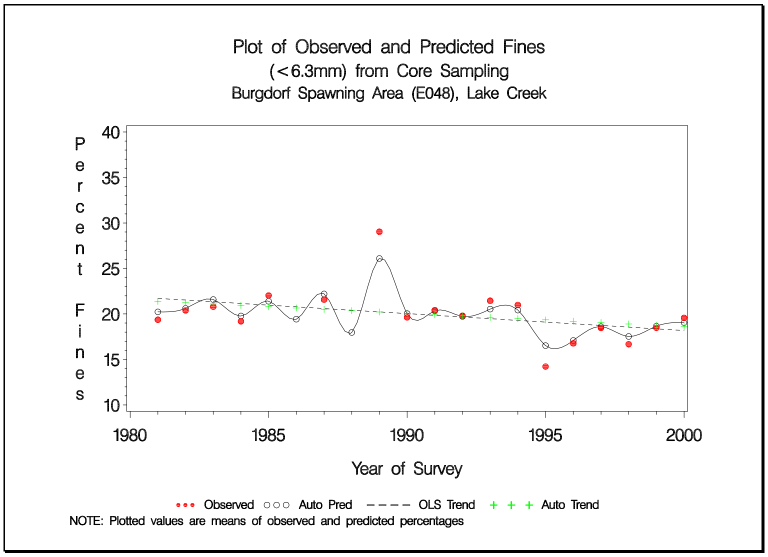

Figure 58.—Time trends in large fine sediments in the Burgdorf spawning area, Lake Creek, 1981-2000.

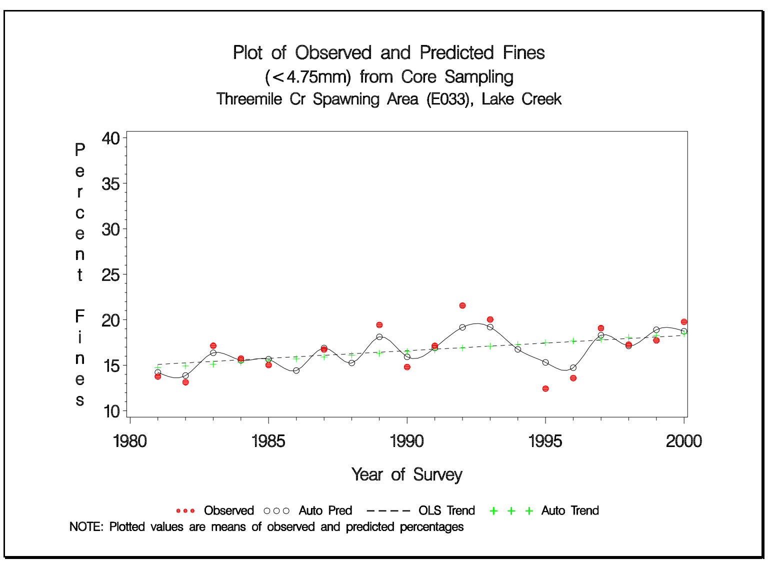

Figure 59.—Time trends in coarse fine sediments in the Burgdorf spawning area, Lake Creek, 1977-2000.

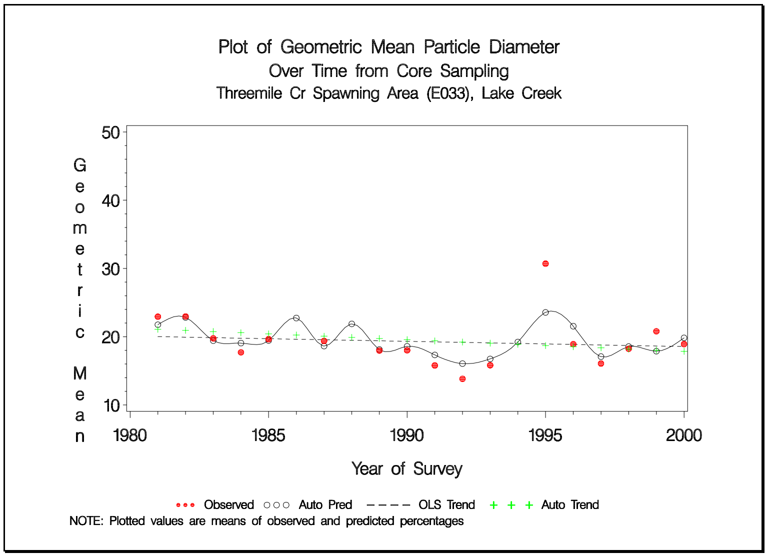

Figure 60.—Time trends in geometric mean particle diameter in the Burgdorf spawning area, Lake Creek, 1981-2000.

Secesh Meadows

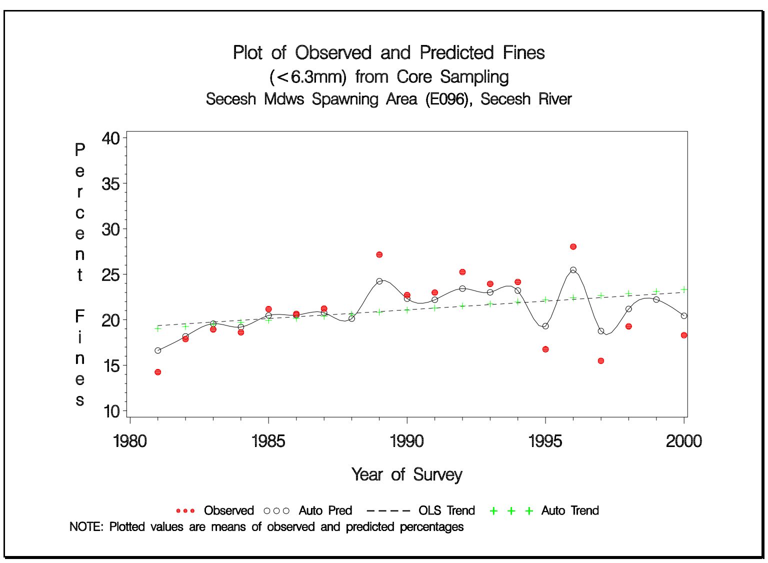

Figure 61.—Time trends in large fine sediments in the Secesh Meadows spawning area, Secesh River, 1977-2000.

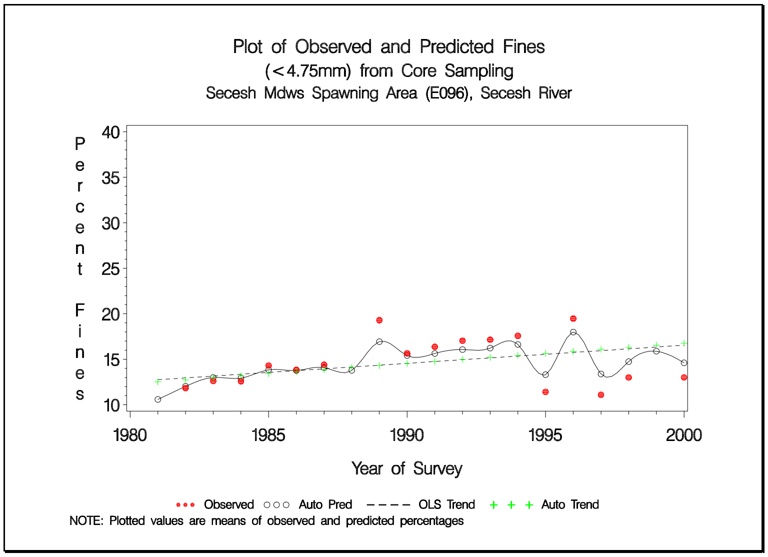

Figure 62.—Time trends in coarse fine sediments in the Secesh Meadows spawning area, Secesh River, 1977-2000.

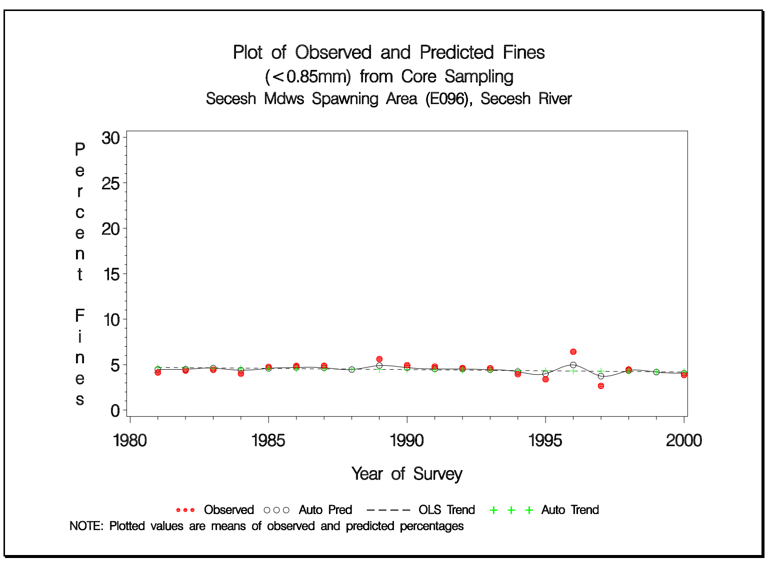

Figure 63.—Time trends in small fine sediments in the Secesh Meadows spawning area, Secesh River, 1977-2000.

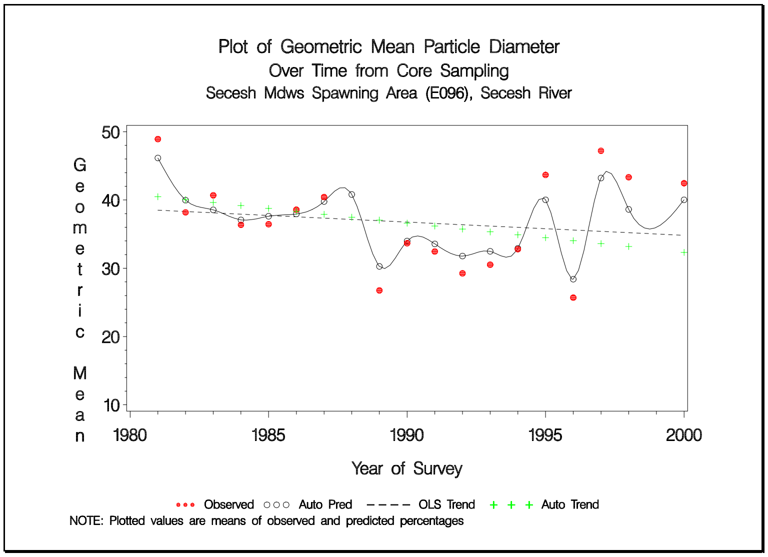

Figure 64.—Time trends in geometric mean particle diameter in the Secesh Meadows spawning area, Secesh River, 1977-2000.

Chinook Campground

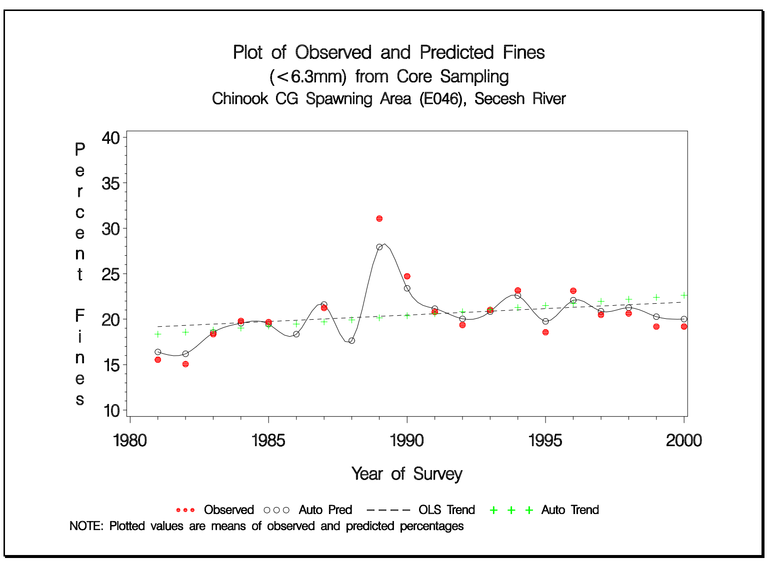

Figure 65.—Time trends in large fine sediments in the Chinook Campground spawning area, Secesh River, 1977-2000.

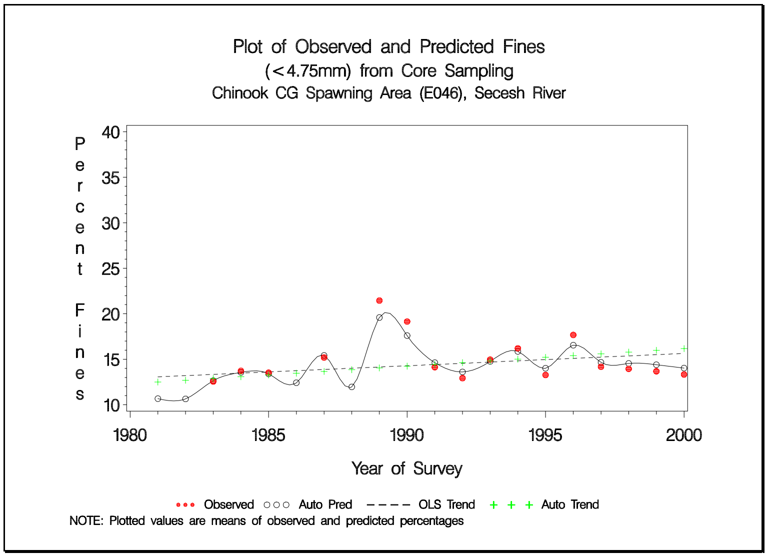

Figure 66.—Time trends in coarse fine sediments in the Chnook Campground spawning area, Secesh River, 1977-2000.

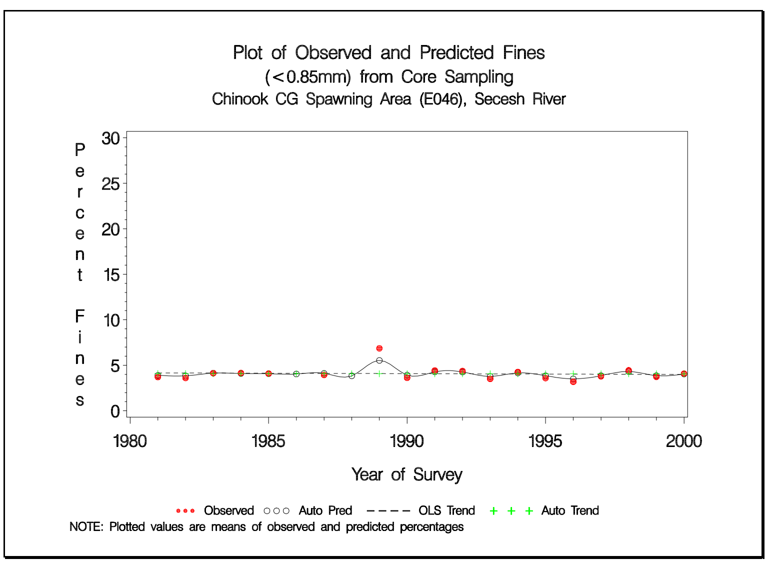

Figure 67.—Time trends in small fine sediments in the Chinook Campground spawning area, Secesh River, 1977-2000.

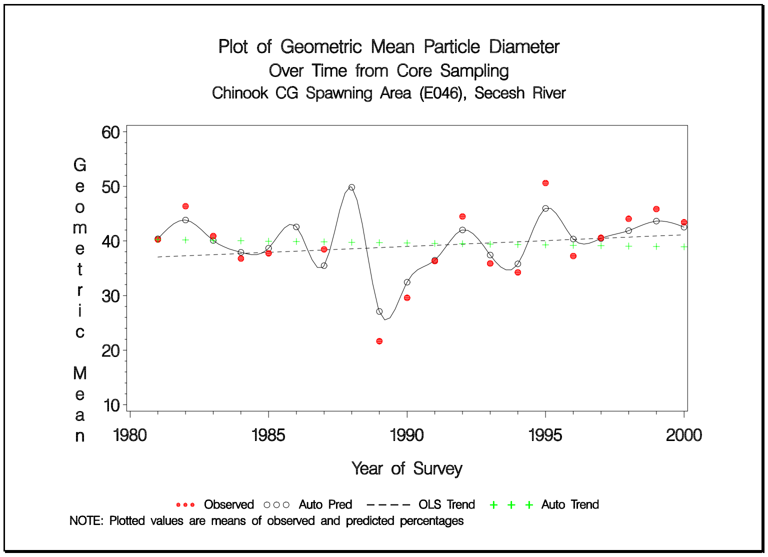

Figure 68.—Time trends in geometric mean particle diameter in the Secesh Meadows spawning area, Secesh River, 1977-2000.

Overall — Dual Trend Models

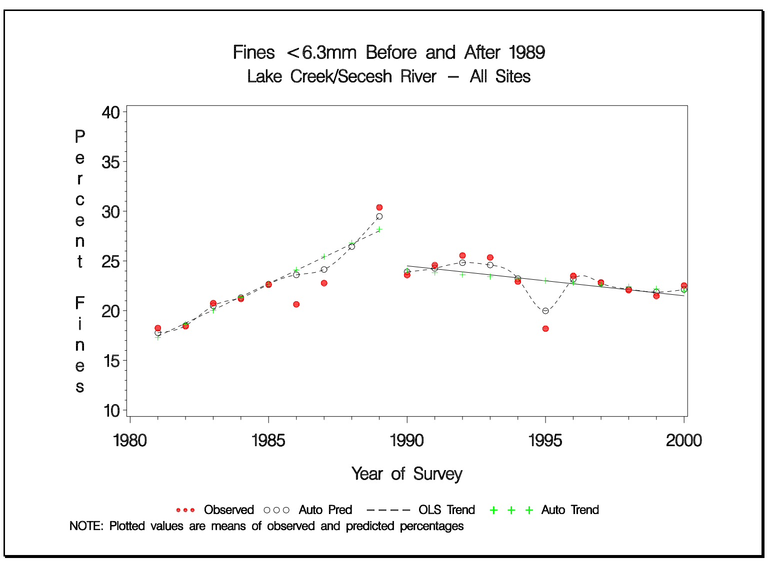

Figure 69.— Time trends in large fine sediments in the Lake Creek/Secesh River spawning areas, up to and after 1989.

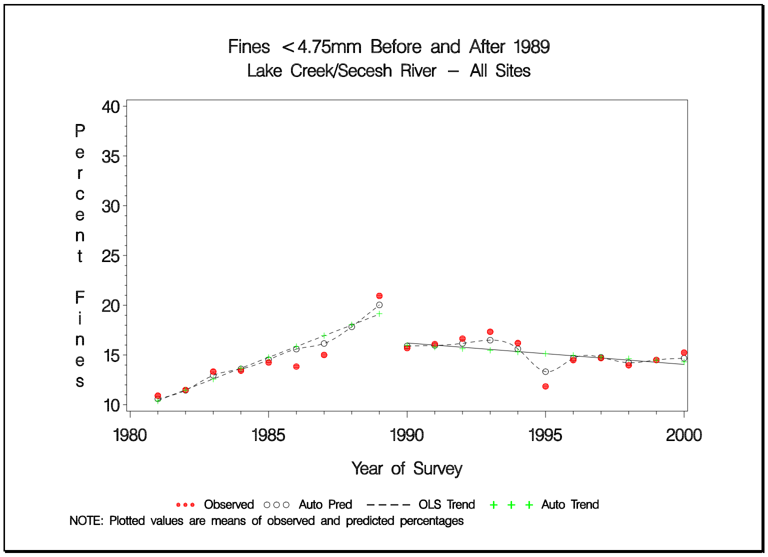

Figure 70.— Time trends in coarse fine sediments in the Lake Creek/Secesh River spawning areas, up to and after 1989.

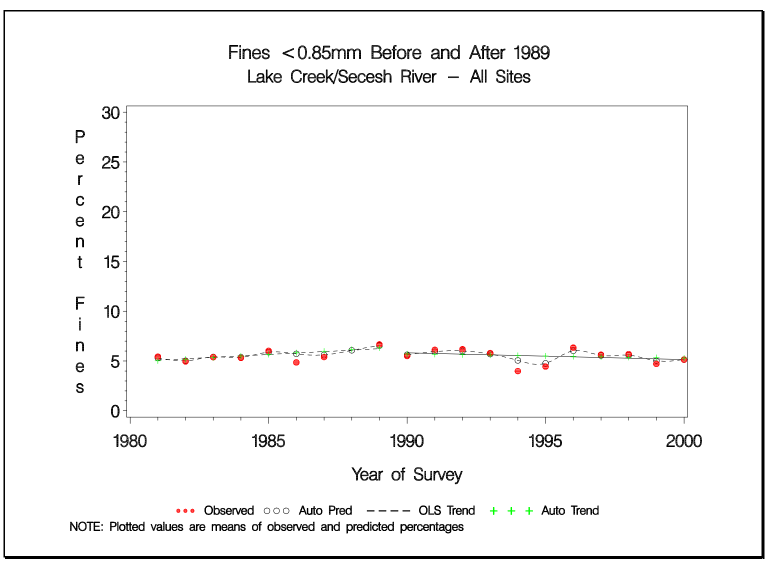

Figure 71.— Time trends in small fine sediments in the Lake Creek/Secesh River spawning areas, up to and after 1989.

CHAMBERLAIN BASIN

Chamberlain Creek

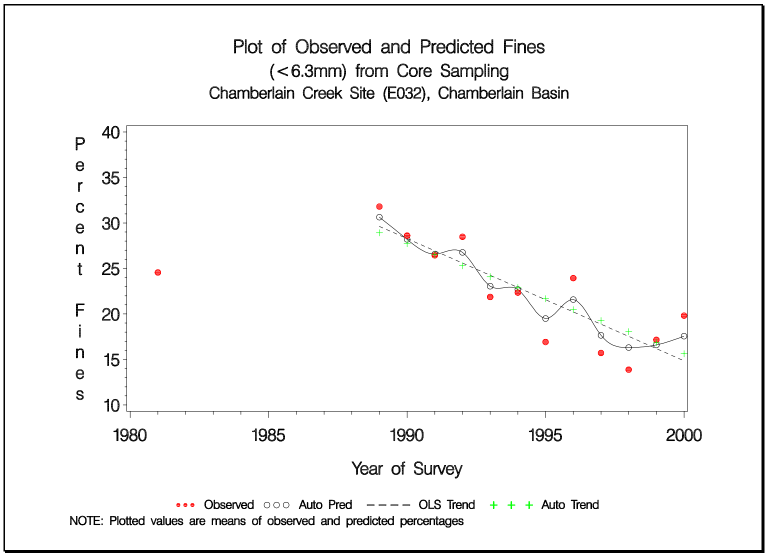

Figure 72.—Time trends in large fine sediments in the Chamberlan Creek spawning area, Chamberlain Basin, 1981 and 1989-2000.

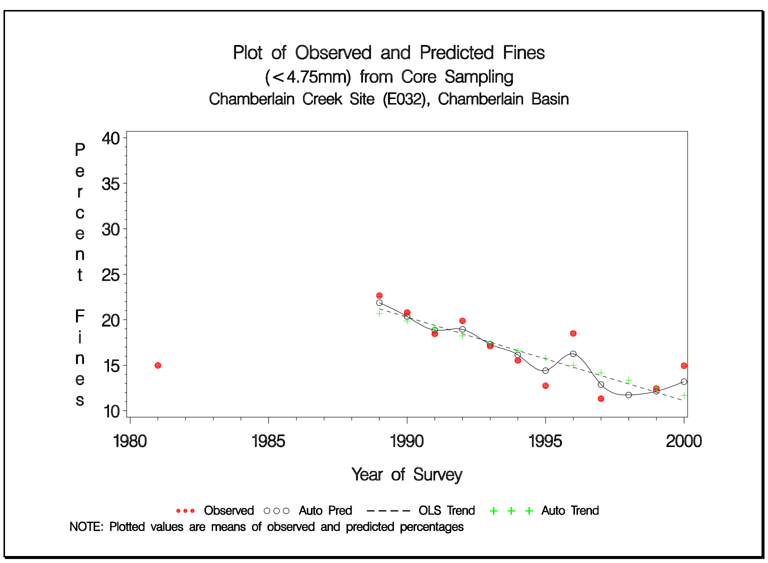

Figure 73.—Time trends in coarse fine sediments in the Chamberlain Creek spawning area, Chamberlain Basin, 1981 and 1989-2000.

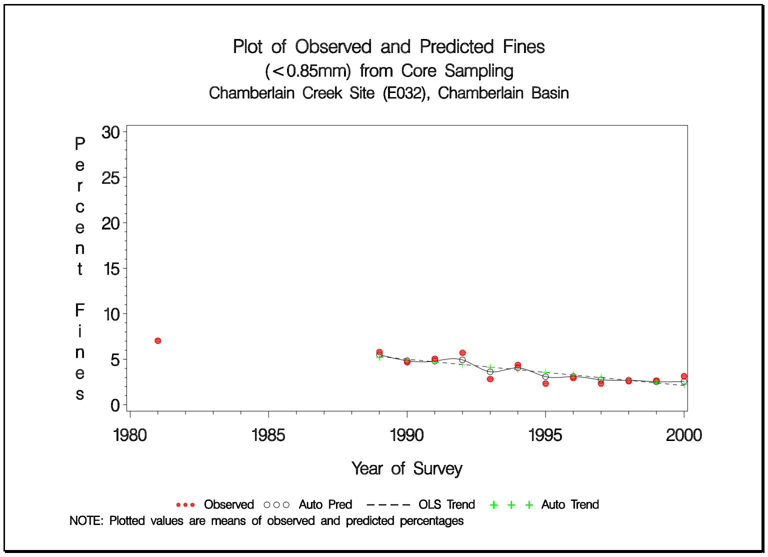

Figure 74.—Time trends in small fine sediments in the Chamberlain Creek spawning area, Chamberlain Basin, 1981 and 1989-2000.

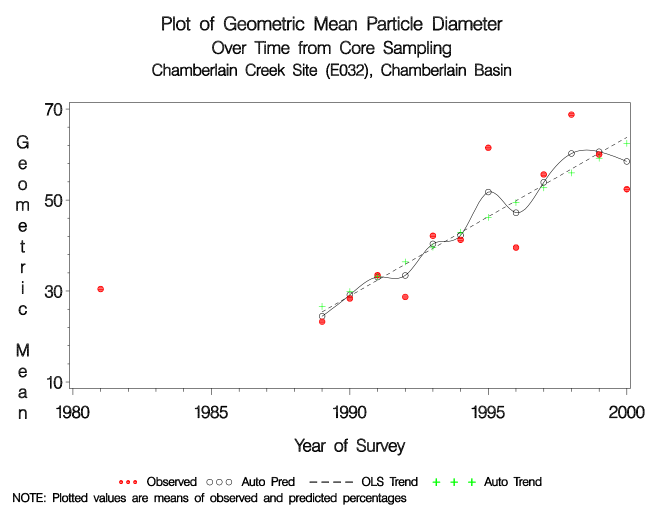

Figure 75.—Time trends in geometric mean particle diameter in the Chamberlain Creek spawning area, Chamberlain Basin, 1981 and 1989-2000.

West Fork Chamberlain Creek

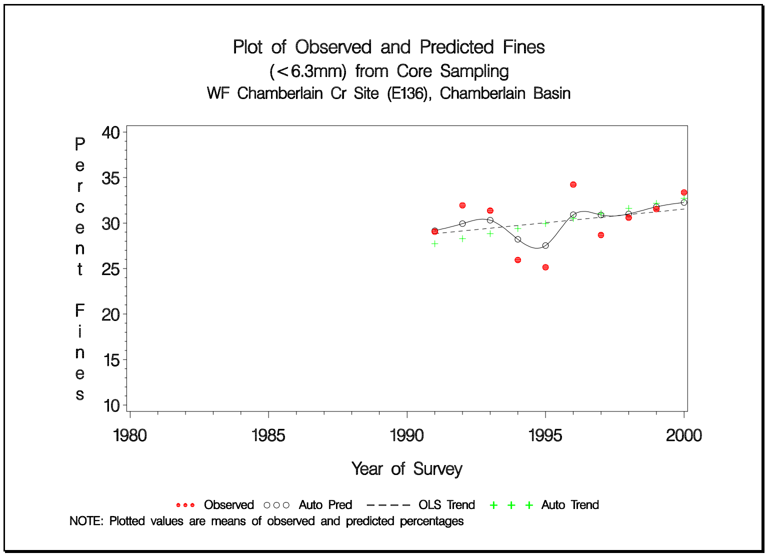

Figure 76.—Time trends in large fine sediments in the West Fork Chamberlain Creek spawning area, Chamberlain Basin, 1991-2000.

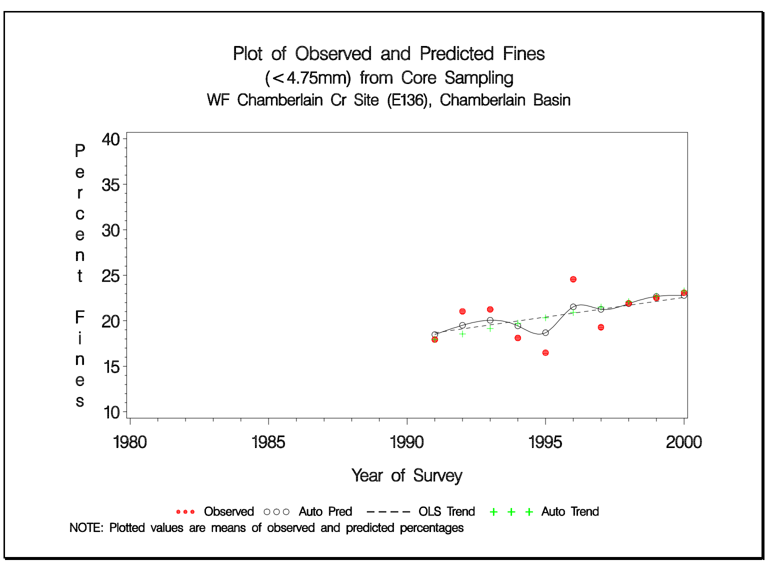

Figure 77.—Time trends in coarse sediments in the West Fork Chamberlain Creek spawning area, Chamberlain Basin, 1991-2000.

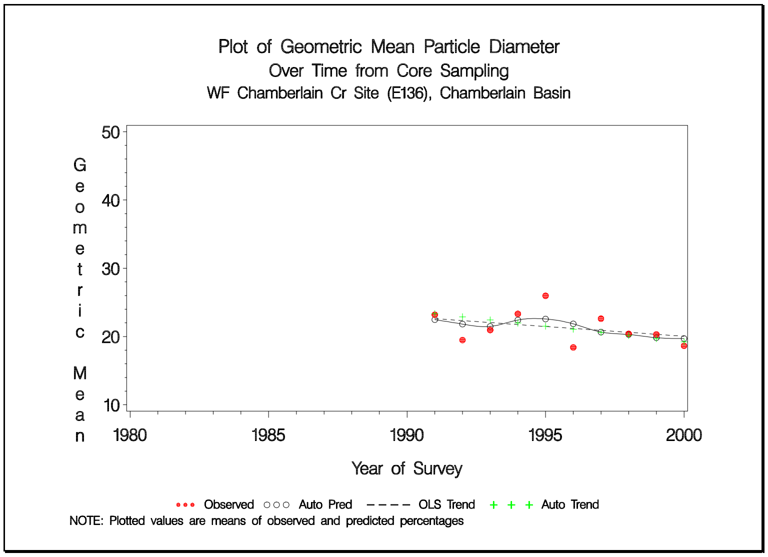

Figure 78.— Time trends in geometric mean particle diameter in the West Fork Chamberlain Creek spawning area, Chamberlain Basin, 1991-2000.

APPENDIX IV: HISTORICAL AND RECENT PHOTOS

(Begins on Next Page)

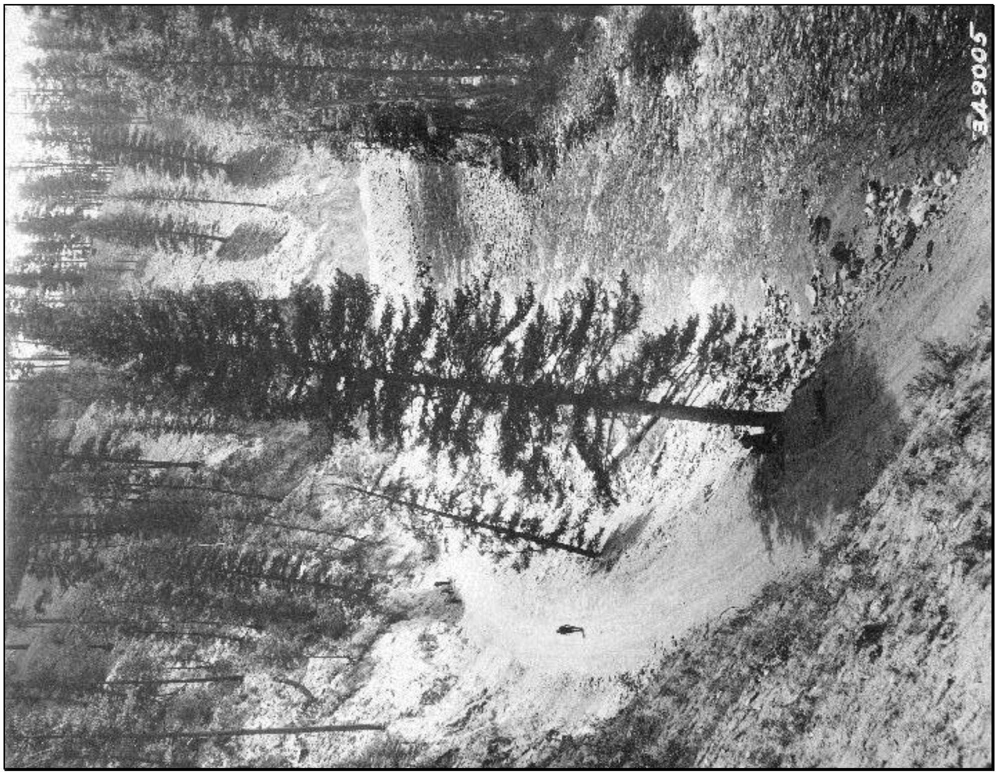

Figure 79.—South Fork Salmon River downstream of the confluence of Buckhorn Creek, 1937.

Figure 80.—South Fork Salmon River downstream of the confluence of Buckhorn Creek, 2000.

Figure 81.—South Fork Salmon River at Poverty Flat, ca. 1938.

Figure 82.—South Fork Salmon River at Poverty Flat, 2000.

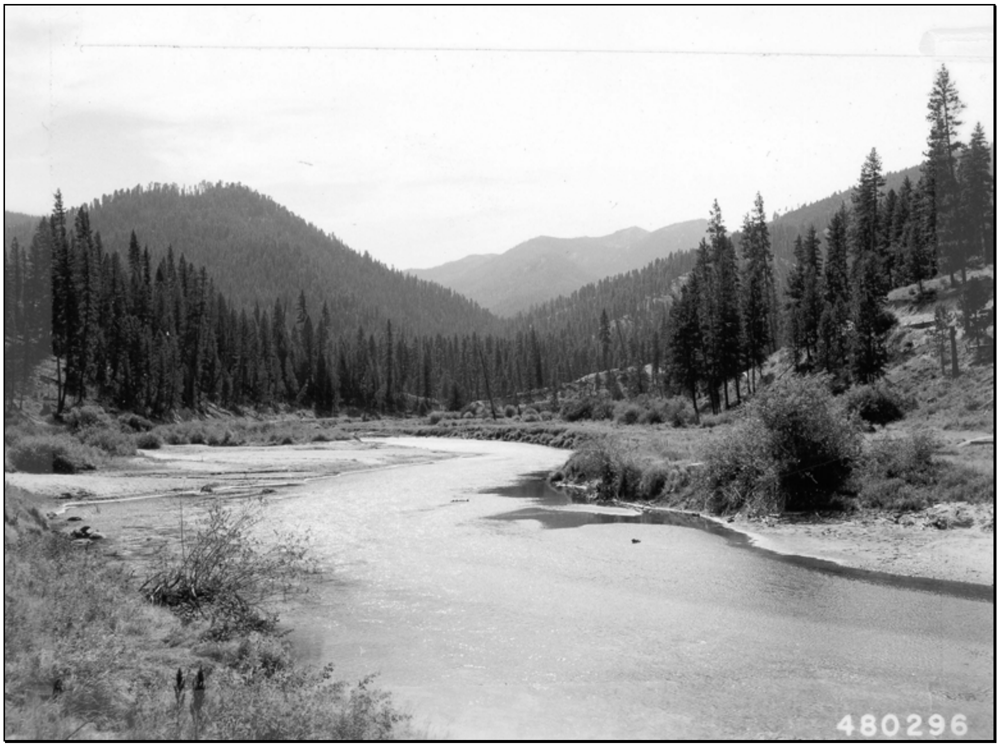

Figure 83.—South Fork Salmon River downstream of the confluences of Phoebe and Camp Creeks, 1955.

Figure 84.—South Fork Salmon River downstream of the confluences of Phoebe and Camp Creeks, 2000.

Figure 85.—South Fork Salmon River in the “Binwall” area, 1965.

Figure 86.— South Fork Salmon River in the “Binwall” area, 2001.